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RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 10, Number 10, October 1969

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Bureau of Radiological Health, Public Health Service.

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Reports

Experience of the State of Illinois Department of Public Health Following the Enactment of a Laser System Registration Law

Russell W. Courtney[1]

The experience of the State of Illinois Department of Public Health, following the enactment of a laser registration law, is presented. The priorities suggested for the inspection of laser systems are (1) high intensity laser systems applied in industrial processes, (2) lower intensity laser systems used in outdoor processes that could potentially expose the general public, (3) lasers used in research institutions, and (4) lasers used as high school and college teaching instruments. At the time of this report, only one accident had been reported to the Department of Health. This accident was a case of electrical shock in which there was no serious injury or loss of work time for the employee.

Illinois enacted the first law in the country relating to laser radiation. This act was known as the Laser System Registration Law.[2] The law requires every operator of a laser system to register such system with the Director of Public Health prior to January 1, 1968, and "to report to the Department any accidental injury to any individual in the course of use, handling, operation, manufacture, or discharge of any laser system." The law also authorizes the Department to investigate and inspect all laser systems in the State for the purpose of studying and evaluating the potential hazard to the health of the people of this State caused by the use and operation of laser systems.

In accordance with the responsibilities vested in the Department of Public Health under the Laser System Registration Law the duties for administration of this Act were placed in the Division of Sanitary Engineering, Bureau of Radiological Health. Personnel from the Bureau of Radiological Health made field visits to most all of the laser installations in the State to explore the uses, applications, and potential exposures of the public to laser radiation.

Under the Laser System Registration Law, the Department of Public Health has a responsibility in controlling public health implications of laser systems much the same as it has for controlling disease organisms in public water supplies, ionizing radiation, or other segments of the environment. Because of the increasing use of laser devices there is a public awareness of the potential hazards from lasers. Lasers of the pulsed, Q-switched type and certain continuous-wave types can produce biological damage, with the eye as the most critical organ. As newer and expanding uses of these devices are discovered, the problems of exposure to occupational and nonoccupational persons will become apparent. Accordingly, it is important to determine in what areas the potential hazards of lasers can be controlled and to propose reasonable standards for the protection of the public without unnecessarily interfering with or hampering the judicious use and application of lasers. To this extent an inspection program was instituted to obtain factual onsite information as to the application of lasers and to determine whether any regulations for the use of these devices were feasible. At the time the inspection program was instituted, laser beam intensities were not measured because there was no suitable survey instrument available. This left certain decisions and impressions up to the judgment of the investigator. While the objectivity of this approach can be questioned, it was the only avenue open to us at the time of the inspection program.

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[1] Mr. Courtney is a sanitary engineer in the Division of Sanitary Engineering, Bureau of Radiological Health, Department of Public Health, Springfield, Ill.

[2] Chapter 111½, paragraphs 701 through 708, Revised Statutes 1967, approved August 11, 1967.

Our survey data have shown that, with one exception, there were no flagrant violations of good "common sense" laser safety. An optometrist was shining the beam of a 1.0 milliwatt helium-neon continuous-wave laser into his patients' eyes for periods of 15 seconds. After our discovery of this practice, the optometrist was restrained from the procedure by the Optometrist Licensing Agency. The use of lasers in high schools and colleges for student instruction was generally observed to be under the supervision of the teacher when the devices were activated. In most instances the laser was locked up in a cabinet or room when not in use to prevent access by unauthorized persons. All of the lasers used in high schools and colleges were of the continuous-wave helium–neon type with outputs on the order of 1.0 milliwatt power maximum. In research and industrial applications the laser systems were used by professional research-scientist personnel.

Most lasers are costly and are not likely to fall into the hands of irresponsible people. Only a few lasers were found in industrial production. These devices were used to align machinery and in tunneling operations.

The administrative practices have been essentially the same as those used in administering the Radiation Installation Registration Law since its passage in 1957. Registration is made as easy as possible for the registrant by requiring him to furnish only such information as type of lasing media, manufacturer, power characteristics, wavelength, pulsed or continuous wave, and use. Any additional specific information needed to evaluate the health and safety hazards is obtained during the physical survey. Our attitude in administering this law is to assist the user and encourage the judicious application of lasers in industry and research without hindrance, while at the same time pointing out any immediate threat to safety or health and providing advice for the abatement of these hazards.

Dr. Wellington Moore, Jr. states in the summary of a recent publication (*1*):

"Concern over the hazards of exposure to laser radiation has resulted in the establishment of guidelines for human exposure by several agencies. Owing to the incompleteness of knowledge concerning biological effects, *particularly long-term ones*, it is not possible to set firm protection standards at this time. Current guides are based upon the minimum dose required to produce a visible lesion. These threshold values may vary depending upon the criteria by which they are measured. For the eye, threshold damage has been determined by such varying means as ophthalmoscopy, light microscopic histology, histochemical study, and electroretinography.

Very little is known about the potential cumulative effects produced by repeated subthreshold exposures either to the eye or skin. Current data in this area are not sufficient to provide information concerning the possibility of cumulative effects from repeated exposures. There appears to be some conflict over the significance of repeated subthreshold exposures in the production of damage.

Occupational hazards incidental to the use of lasers must be reduced to the very minimum. In addition to beam exposure, other potential hazards include contact with liquid nitrogen or other substances such as coolants, electrical shock, exposures to gases such as ozone, and explosions at capacitor banks, optical pump systems, and target area. A complete safety program is necessary to protect the operating personnel and other persons present at laser installations."

There is apparently little evidence of the long term or cumulative effects on the biological systems of laser radiation. For this reason, it is virtually impossible to set maximum permissible limits with any degree of assurance.

Procedure

The survey procedure was generally patterned after survey material prepared by the Bureau of Occupational Safety and Health, Consumer Protection and Environmental Health Service, Environmental Control Administration, U.S. Public Health Service. This information was used to establish a survey protocol for program planning in this State. The main goal of this survey technique was to attempt to define the potential health hazards created by the rapidly expanding application of lasers in industry and educational institutions, in a form comparable with national

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occupational health survey procedures. It was felt that an evaluation of this type was necessary to assess the potential exposure of workers and the public along with present protective measures afforded, before any attempt at standards or regulations is instituted. Only after survey material of this type has been evaluated and the potential hazards from lasers defined can we determine whether present operating procedures and controls are adequate to protect the public health and safety.

While this survey protocol was designed primarily to study the health hazards from laser beams, the survey also considered chemical, electrical, or other environmental factors which might have deleterious effects on the persons in the environs of laser systems.

The first part of the survey was an interview with the appropriate management representative. During this interview, information was obtained relative to the services or product, personnel involved in laser operations, and type of medical program, such as extent of pre-employment, periodical and terminal medical examinations with emphasis on ophthalmological examinations. The safety program was reviewed with observations noted as to the safety director's knowledge or understanding of laser hazards.

The second part of the survey was a walk-through or visual observation of all areas in which laser systems were used. Data were verified regarding the type of laser, manufacturer, model, beam characteristics, output energy, wavelength, and application. Also noted were safety considerations such as warning signs, access control to laser areas, interlocks on entrances, reflectivity of room surfaces, illumination, and eye protective equipment. In high-energy laser areas, observations were made to determine what toxic materials were used or stored in the area, whether toxic target materials were vaporized during laser operations, and whether management was aware of the toxicity of these pollutants. If, during a survey it was found that an immediate potential hazard existed, the investigator provided technical assistance to management in pointing out the potential severity of such hazard and offered suggestions for abatement of the hazard. At the same time he advised management that the Department had no control powers and the recommendations were merely given in the spirit of being helpful in the abatement of such health or safety problems. The visual or walk-through type of survey admittedly does not yield information in adequate detail to determine complete control of all hazards under all the variations of use. These data, however, can be useful for categorizing degrees of hazards for a later, more thorough investigation of the problem to reduce the risk or hazard to public health. In this survey program, we very carefully guarded against projecting any attitude of proposing unrealistic safety measures at the expense of hindrance in the judicious use of lasers.

The Illinois Department of Public Health prepared forms and accepted registrations for laser systems prior to January 1, 1968 as required by the law. To date there have been 57 installations with a total of 184 laser systems registered with the Department. One installation, for example, uses some 70 laser systems in the confines of the institution.

The facilities registrating lasers are distributed by category as follows:

High schools	10
Universities and colleges	15
Industries	28
Optometrists	1
Laser manufacturers	3

Of the 57 registered facilities, 48 have been inspected. In the group of 48 inspections, there were 28 industries, 11 colleges and universities, 3 high schools, 1 research organization, 3 manufacturers and distributors, and 2 others, as shown in table 1.

Table 1. Laser systems surveyed by category and lasing medium, January 1968–March 1969

Laser type	Industries	Colleges and universities	High schools	Research	Manufacturers and distributors	Other	Total
Helium-neon	38	38	3	9	22	1	111
Ruby	5	5		1		1	12
Carbon dioxide	1	1					2
Argon	1	1					2
Neodymium	2	1					3
Gallium - arsenic	2						2
Total lasers surveyed	49	46	3	10	22	2	132
Total registrants surveyed	28	11	3	1	3	2	48

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The inspections tabulated "as others" were 1 optometrist, and 1 State medical institution. Of the 111 helium-neon gas lasers inspected, 14 were rated above 3.0 milliwatts. Two of the 14 were rated at 50.0 milliwatts (the maximum output in the group).

The ruby lasers, all of which were pulsed, ranged in intensities from 1.0 joule to 100 megawatts. All of the installations having ruby-pulsed lasers provided eye protective devices manufactured by two leading firms supplying eye protective equipment for wave lengths of 6,000 to 8,000 Å

The following are descriptions of some of the applications of lasers by the industrial users.

Machine alignment A helium-neon laser of the continuous-wave type at 6,328 Å and 15 microwatts power is used to traverse the bed of a computerized milling machine. The laser is installed on one end of the milling-machine bed and the beam is transmitted to a reflecting prism at the opposite end of the bed. The beam is then reflected back to the photoelectric cell adjacent to the laser head. Analysis of the beam by a computer determines horizontal travel and depth of cut of the milling head. The depth of cut can be determined to a tolerance of 17×10^{-6} inch. Once programmed, the machine performs cutting, drilling, and tapping operations automatically as commanded by the computer. The entire laser unit and photocell is contained in a steel housing and is permanently mounted on the milling machine. The beam traverses the machine cutting bed 8 inches above the base and is not subject to direct viewing by passersby or machine operators. The machine is in the experimental stages and if proven successful, will be sold to automotive and other large machine manufacturers.

Another plant attempted unsuccessfully to incorporate a 1.0 milliwatt laser in a device for alignment of 120-foot-long milling machine beds to a tolerance of 0.0001 inch. Because of wave interferences, vibrations, and air movements, the use of this device was discontinued.

Earth moving machinery A research program for controlling the height of cut of a motor grader in cut-and-fill operations at an industrial plant uses a laser mounted vertically in a 5-inch-diameter steel tube in the center of a tripod. The laser beam is directed upward, striking a pentaprism mirror mounted in a turret at the top of the steel tube approximately 8 feet above grade. The motorized turret revolves at 300 rpm and allows the beam to sweep an area of 360° to a distance of 500 feet. The motor grader is equipped with a series of solar cells mounted on an antenna placed well above the head of the operator. The beam signal, then received at a specific height on the antenna, is amplified, and recorded on instruments which are calibrated to determine the depth of cut or height of fill to be made by the machine from the preestablished reference point. The grader can be operated up to distances of 500 feet from the laser sending station. The laser is a 1.0 milliwatt, helium-neon continuous wave device having a 2-millimeter beam diameter at the aperture and 0.4 milliradian divergence. The rotating mirror turret is electrically connected in series with the laser generator in a manner such that if the turret stops rotating, the laser is inactivated. Because of the rotational characteristics of the pentaprism mirror, and considering a laser sending power level of 1.0 milliwatt, the probability of this application creating a safety hazard to observers appears small if operated as designed.

Another operation at this plant employs a 1.0 milliwatt, helium-neon continuous-wave laser to determine the roundness of an orifice for a fuel-injection nozzle and to measure flatness of steel surfaces in research projects.

Public relations One telephone company uses a laser for demonstrating to public groups the sound carrying capability of laser beams. The laser is a 5-milliwatt, helium neon, continuous-wave portable device. A record player is connected to the laser head and sound is transmitted by the beam to a photoelectric cell—amplifier speaker arrangement. When the beam is intercepted, sound at the speaker is interrupted, demonstrating that the sound is transmitted on the laser beam. Audiences are reminded not to look into the direct beam. This system is distributed through 11 of the company's operating branches throughout the country.

Tunneling The laser beam is used as a navigational aiming device in tunnel construction. The laser is a 5.0 milliwatt, helium-neon continuous-wave device. The laser head is mounted on the tunnel wall and the beam is focused on a target mounted on the boring machine some distance forward and above the head of the operator. The positioned laser beam strikes a mark on the target and by observing the light spot from the laser,

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the operator can continuously maintain the correct vertical and horizontal direction of the boring face for distances up to 400 feet without resetting the laser. In this instance, the "mole" was drilling a hole 14 feet in diameter.

No safety goggles for lasers are provided for the operator as management feels there is no danger to the eye because of the low-power output of the laser. In addition, goggles for the wavelength of a helium-neon laser would reduce visibility and expose the operator to other hazards in the environment.

Laser manufacturing One company which was inspected manufactures the complete laser system including the glass-lasing tube, mirror system, and electrical components. At the time of inspection, this company manufactured only the helium-neon continuous-wave lasers in the 1.0 to 2.5-milliwatt range, at a production capacity of 18 systems per day. Because of the low energy characteristics of the lasers manufactured in this plant, no special eye protective devices are provided for the employees.

There is also a company engaged in the manufacture of a sewer line and grade alignment system incorporating a 1.3 milliwatt, helium neon, continuous-wave laser as a light source. This is a small operation with an output of 3 to 4 units per month and employing 3 technicians at the present time. The device has a warning sign "Laser Beam—No Direct Viewing."

Spectroscopic application A Q-switched, 1.0 joule, neodymium-doped glass laser is used in conjunction with a microprobe spectroscope as a heat source for vaporizing metal samples and as a partial light source for spectroscopic analysis of these metals. The metals used in electrical components are copper, silver, gold, cadmium, lead, mercury, and so forth. The sample is placed on the microscope stage and a small area is vaporized by the laser beam. The binocular microscope is used for alignment of the sample and for viewing the results of the destructive analysis of the sample. The room in which this testing was being done was rather small, was crowded with laboratory apparatus and had no mechanical ventilation. Some of the metals (especially lead, cadmium, and mercury) when vaporized could create a potential health hazard by building up a residue of fumes and particulates in the room. A small local exhaust ventilation system was provided for ventilating the carbon arc (an integral part of the spectroscope). It was recommended that a small local exhaust hood be provided around the periphery of the sample vaporizing area and connected to the existing exhaust system for the carbon arc.

Summary and conclusions

1. The Laser System Registration Law with its survey requirements has provided the Illinois Department of Public Health with the authority to evaluate the public health implications of lasers and other areas of radiation in the electromagnetic spectrum.

2. By continuing the registration and inspection of lasers, the Department can provide a reservoir of information in this new field of radiation. The Department will serve as a collection and dissemination agency from which the public and interested groups may obtain information on public health problems that may evolve from the use of these devices.

3. Until more specific details are available on the subthreshold and long-term biological effects due to lower energy laser radiation exposures, there should be no exemption from the registration requirements.

4. There is a need to continue the inspection program to keep abreast of new developments as they arise in the laser field. These inspections should be conducted on a priority basis; however, they should not be based only on the severity of the potential hazard to individuals in-plant, but also on the degree of epidemiological impact that laser radiation might have on the public when used in an offsite outdoor environment. The suggested priorities are as follows:

   a. high intensity laser systems applied in industrial processes,

   b. lower intensity laser systems used in outdoor processes that would potentially expose the general public, such as surveyor and sewer alignment instruments, traffic control, and so forth,

   c. lasers used in research institutions, and

   d. lasers used as high school and college teaching instruments.

5. Because of the paucity of information on subthreshold and long-term effects of laser radiation on the biological system it would be premature, in our opinion, to establish standards for

control of laser users at this time. The laser problem might best be handled on the basis of a continued educational approach and provisions for assistance in matters of safe laser operation upon request from users. Furthermore, in view of the provisions of Public Law 90-602 entitled "Radiation Control for Health and Safety Act of 1968," Sec. 360f, it would appear that in the near future Federal Standards developed under this law would supersede any State regulations which were not completely compatible with these standards.

6. During our inspections, we impressed upon the registrants that the purpose of the law was merely to give the Department the authority to locate laser systems and to study the potential or real health hazards arising out of the use of lasers and assured them that there were no provisions for controls of such use. It was our philosophy that indiscriminate use of such a law could hamper the judicious use of lasers.

7. At the time of this report, the only accident reported to this Department was one case of electrical shock in which there was no serious injury or loss of work time for the employee.

REFERENCE

(*1*) MOORE, WELLINGTON, JR. Biological aspects of laser radiation, a review of hazards. Report, Research Branch, National Center for Radiological Health, Rockville, Md. 20852 (Reprinted January 1968).

A Comparison of the Cesium-137 Content of Milk and People From 19 Dairy Farms in Utah[1]

R. D. Lloyd, C. W. Mays, R. C. Pendleton, and *D. O. Clark*[2]

Measured cesium-137 concentration (pCi ^{137}Cs/g K) in milk from 19 Utah dairy farms and in residents of those farms, have been compared for the period 1962 through 1966. During the time when cesium-137 levels were increasing (1962–1964), the cesium-137 to potassium ratios in people were similar to the ratios in milk produced by the dairy farm on which they resided. During the time when cesium-137 levels were decreasing (1964–1966) the ratios in people averaged about 2.5 to 4 times higher than the milk. Differences in biological half-times of cesium for men, women, and children are reflected in their respective body concentrations of cesium-137. This comparison suggests that measured cesium-137 to potassium ratios of milk might be used to estimate the cesium-137 concentration of a population with similar dietary habits during a corresponding time period without considering such factors as milk intake or the consumption of non-milk foods. Preliminary analysis of the relationship between milk levels and body cesium-137 concentration of individual subjects indicates that milk cesium-137 data can be used with appropriate human biological half-times to estimate the shape of human ^{137}Cs/K curves for the same time period.

As part of a study of the accumulation of cesium-137 under different ecological conditions, body burdens of cesium-137 and potassium in residents of a number of Utah dairy farms (figure 1), (*1–2*) were determined periodically from 1962 to 1966 by total body counting. These measurements provided an opportunity to compare cesium-137 levels in this group of people with cesium-137 levels in milk from the dairy farms on which they resided. Milk was collected monthly or semimonthly from each of these farms and was analyzed for cesium-137 and potassium (determined from potassium-40 content) by gamma-ray spectroscopy. Methods used to determine the levels of gamma-ray emitters in milk (*2–3*), and in humans (*2, 4, 5*) have been described. Our human counting techniques have been evaluated in references (*6*) and (*7*).[3]

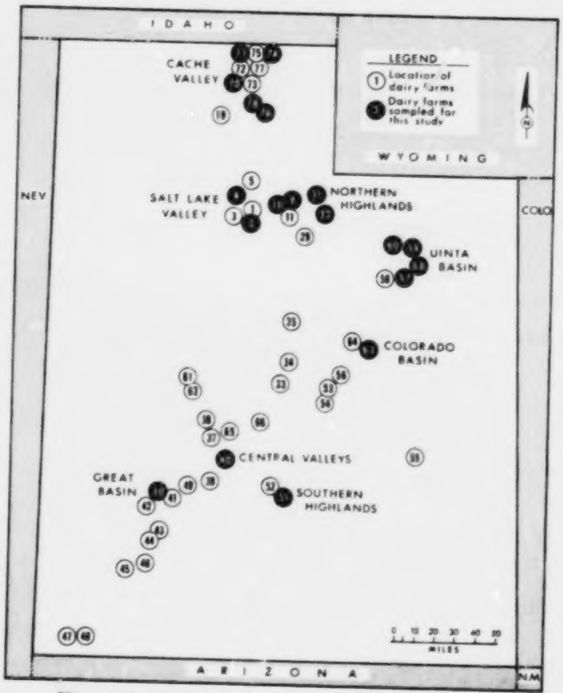

Figure 1. Sampling locations of dairy farms

Results of milk and human counting are plotted in figures 2 through 20 for the 19 farms for which we had at least 2 years of human data and concurrent milk collections. In making this comparison of people and milk, cesium-to-potassium ratios (pCi ^{137}Cs/g K) were employed. This allowed the milk and human data to be expressed in the same units. In addition, milk data and human data were of about the same magnitude when these units were employed. Ratios of cesium-137 to

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[1] Supported by a U.S. Public Health Service, Bureau of Radiological Health Grant RH-30.

[2] Mr. Lloyd and Dr. Mays are members of the Department of Anatomy and Dr. Pendleton is a member of the Department of Radiological Health, University of Utah, Salt Lake City, Utah. Mr. Clark was with the Department of Anatomy, University of Utah and is presently at the Duke University Medical Center, Durham, N.C.

[3] Participating laboratory number 15.

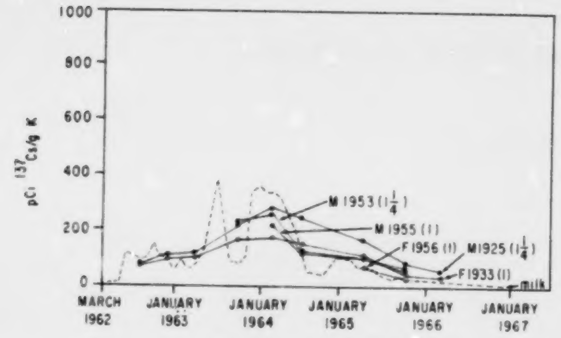

Figure 2. Comparative $^{137}Cs/K$ ratios for milk and people from dairy farm #2, Salt Lake Valley (Sex, year of birth, and estimated average daily milk consumption in liters shown for each subject)

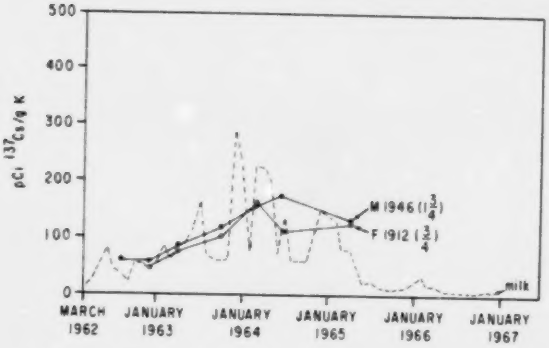

Figure 3. Comparative $^{137}Cs/K$ ratios for milk and people from dairy farm #4, Salt Lake Valley (Sex, year of birth, and estimated average daily milk consumption in liters shown for each subject)

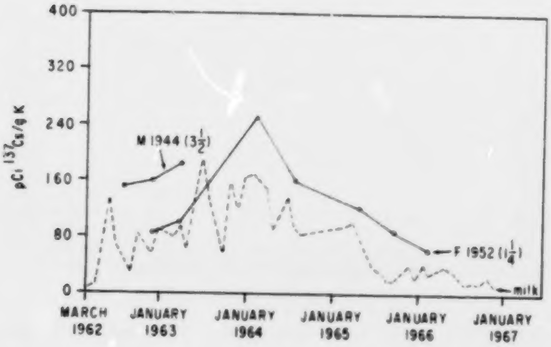

Figure 4. Comparative $^{137}Cs/K$ ratios for milk and people from dairy farm #9, Northern Highlands (Sex, year of birth, and estimated average daily milk consumption in liters shown for each subject)

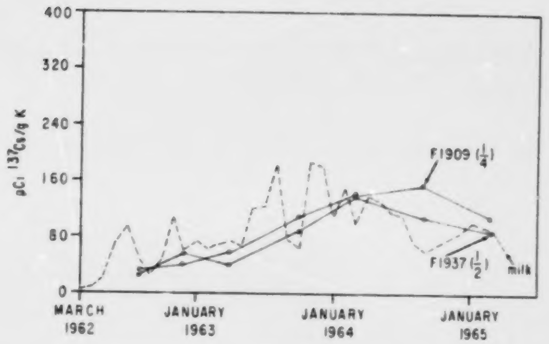

Figure 5. Comparative $^{137}Cs/K$ ratios for milk and people from dairy farm #10, Northern Highlands (Sex, year of birth, and estimated average daily milk consumption in liters shown for each subject)

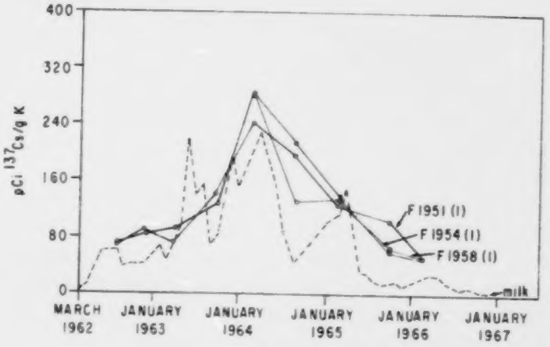

Figure 6. Comparative $^{137}Cs/K$ ratios for milk and people from dairy farm #31, Northern Highlands (Sex, year of birth, and estimated average daily milk consumption in liters shown for each subject)

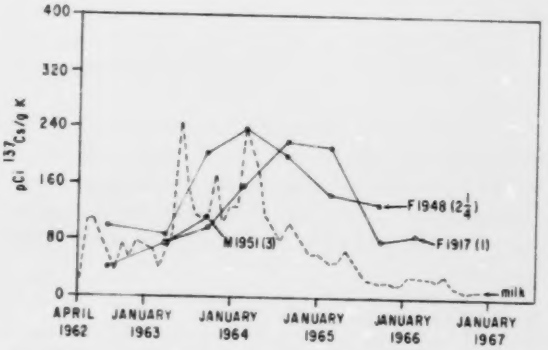

Figure 7. Comparative $^{137}Cs/K$ ratios for milk and people from dairy farm #32, Northern Highlands (Sex, year of birth, and estimated average daily milk consumption in liters shown for each subject)

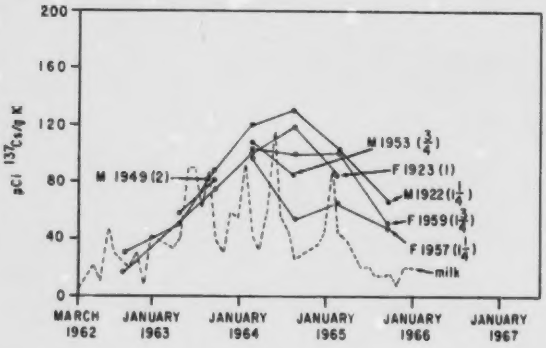

Figure 8. Comparative ^{137}Cs/K ratios for milk and people from dairy farm #40, Central Valleys
(Sex, year of birth, and estimated average daily milk consumption in liters shown for each subject)

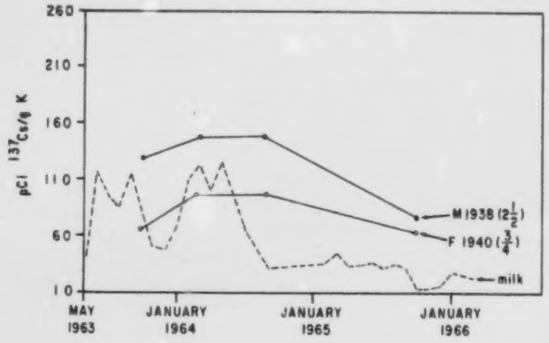

Figure 9. Comparative ^{137}Cs/K ratios for milk and people from dairy farm #50, Great Basin
(Sex, year of birth, and estimated average daily milk consumption in liters shown for each subject)

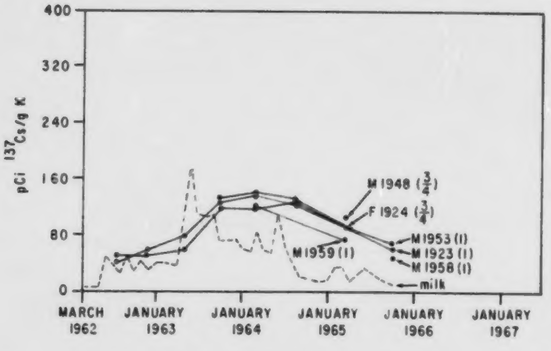

Figure 10. Comparative ^{137}Cs/K ratios for milk and people from dairy farm #51, Southern Highlands
(Sex, year of birth, and estimated average daily milk consumption in liters shown for each subject)

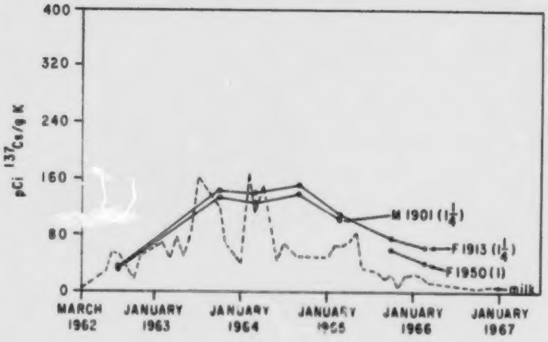

Figure 11. Comparative ^{137}Cs/K ratios for milk and people from dairy farm #57, Uinta Basin
(Sex, year of birth, and estimated average daily milk consumption in liters shown for each subject)

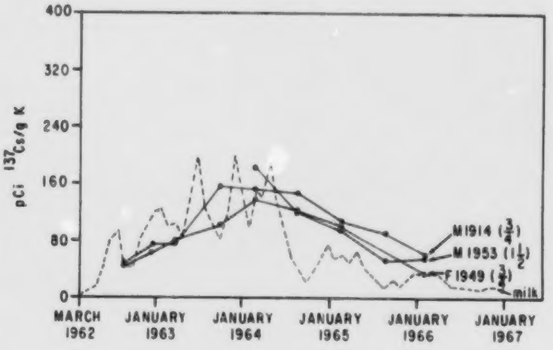

Figure 12. Comparative ^{137}Cs/K ratios for milk and people from dairy farm #60, Uinta Basin
(Sex, year of birth, and estimated average daily milk consumption in liters shown for each subject)

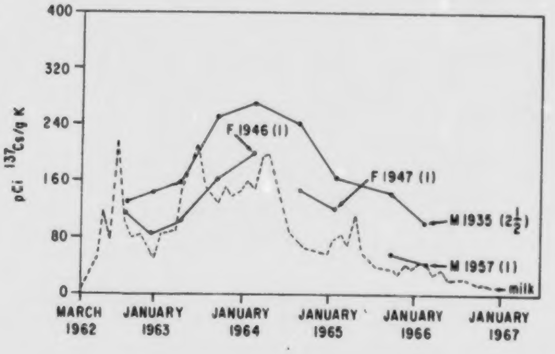

Figure 13. Comparative ^{137}Cs/K ratios for milk and people from dairy farm #60, Uinta Basin
(Sex, year of birth, and estimated average daily milk consumption in liters shown for each subject)

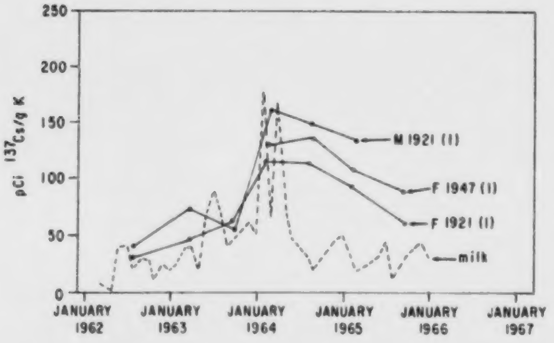

Figure 14. Comparative ^{137}Cs/K ratios for milk and people from dairy farm #63, Colorado Basin (Sex, year of birth, and estimated average daily milk consumption in liters shown for each subject)

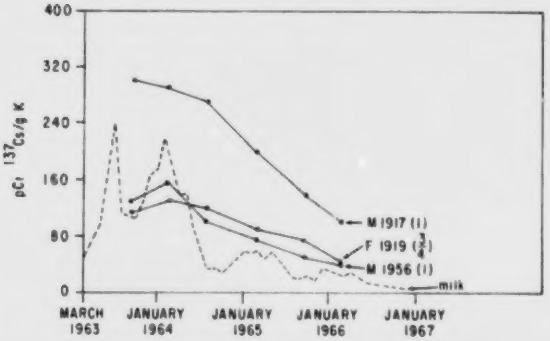

Figure 15. Comparative ^{137}Cs/K ratios for milk and people from dairy farm #68, Uinta Basin (Sex, year at birth, and estimated average daily milk consumption in liters shown for each subject)

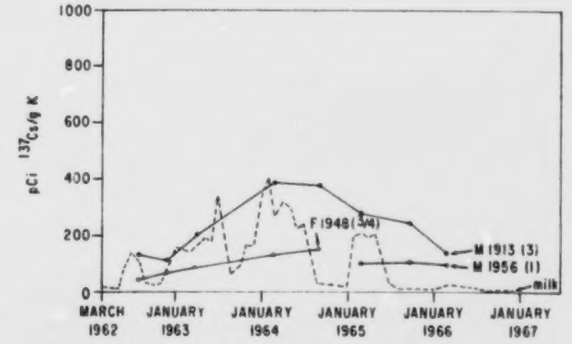

Figure 16. Comparative ^{137}Cs/K ratios for milk and people from dairy farm #70, Cache Valley (Sex, year of birth, and estimated average daily milk consumption in liters shown for each subject)

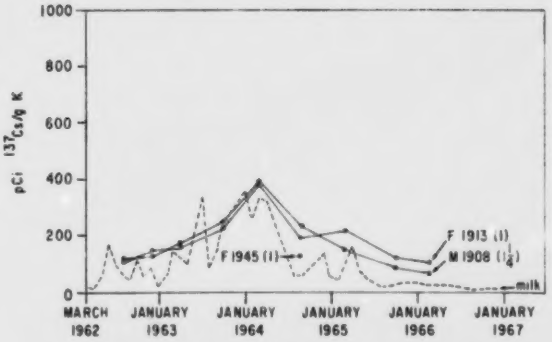

Figure 17. Comparative ^{137}Cs/K ratios for milk and people from dairy farm #71, Cache Valley (Sex, year at birth, and estimated average daily milk consumption in liters shown for each subject)

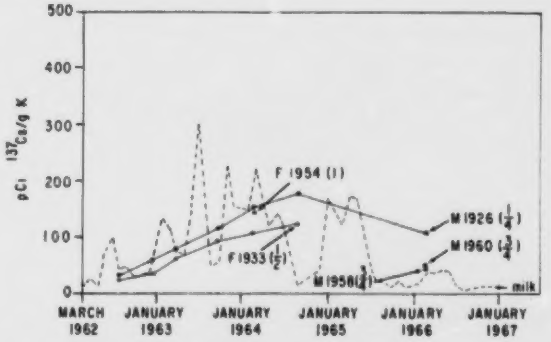

Figure 18. Comparative ^{137}Cs/K ratios for milk and people from dairy farm #74, Cache Valley (Sex, year of birth, and estimated average daily milk consumption in liters shown for each subject)

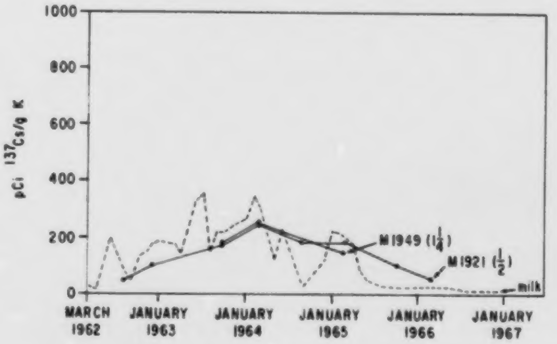

Figure 19. Comparative ^{137}Cs/K ratios for milk and people from dairy farm #76, Cache Valley (Sex, year at birth, and estimated average daily milk consumption in liters shown for each subject)

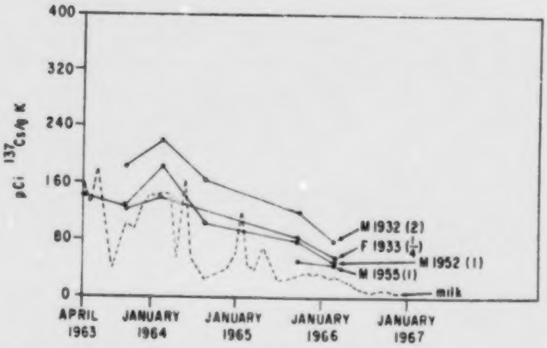

Figure 20. Comparative ^{137}Cs/K ratios for milk and people from dairy farm #78, Cache Valley (Sex, year of birth, and estimated average daily milk consumption in liters shown for each subject)

potassium within a family were much more uniform than cesium-137 body burdens. An example of this relationship is shown in figure 6. The cesium-137 to potassium ratios of these three sisters were similar although their cesium-137 body burdens differed by factors of 2 to 3.

Concentrations of cesium-137 in milk in pCi/liter for any month may be obtained by multiplying the cesium-137 to potassium ratio by the approximately constant average potassium concentration measured for the milk in this study (1.59 ± 0.18 g K/liter).[4] Concentrations of cesium-137 in the human body may be estimated by multiplying the cesium-137 to potassium ratios by the average potassium concentration of humans (*8*), about 2.10 ± 0.23 g K/kg for males, and 1.78 ± 0.26 g K/kg for females.[4] Since the healthy human is in potassium equilibrium, his potassium content is not controlled by his potassium intake but changes mainly as a result of growth or wasting.

Month-by-month variations in milk values seen in figures 2 to 20 are real and represent periods when cattle consumed feed of varying cesium-137 content. Typically, Utah dairy farmers harvest three crops of hay during the growing season; the first crop, grown in the spring when rainfall is at a maximum usually contains a higher concentration of cesium-137 than the subsequent two crops. Whenever this first crop of hay is fed to cattle, the concentration of cesium-137 in their milk increases. It decreases when they are fed the material less rich in cesium-137. Local fallout can alter this general pattern, and a unique series of peaks and valleys in the milk data can occur when cattle are shifted from one type of feed to another, such as from dry hay to grazing or to freshly-cut alfalfa. First crop hay, held for several months before feeding, can produce a cesium-137 maximum in milk even during the winter.

Figures 2 to 20 reveal that, in general, the ^{137}Cs/K in milk is reflected in the ^{137}Cs/K in people who consume that milk. Month-by-month fine structure in the milk curve, however, is not evident in the curves representing humans. Several factors are responsible for this, among which are:

1. human subjects were not measured as often as milk, so some fine structure was undoubtedly missed. This is suggested by the *decreasing* cesium-137 body burdens following the summer 1962 peak in milk for dairy farm stations 4, 32, 51, 60, and 70 (figures 3, 7, 10, 13, and 16) in the face of a generally *increasing* cesium-137 content in food;
2. milk was not the only source of cesium-137 (or potassium) in the diets of these subjects. But for at least some of these families, their milk was the major source of cesium-137 during at least the early part of this study (*9*);
3. the concentration of cesium-137 in milk is determined by the consumption of cesium-137 by the cow when the milk is being produced, so changes in daily feeding are rapidly reflected by changing cesium-137 levels in milk. The human, however, because of his relatively longer retention time for cesium-137, is an integrator of previous and present intake, and his total cesium-137 body burden does not change rapidly when his intake is sharply diminished (*10*).

Human body burdens depend not only on the intake of cesium-137, but also on the characteristic cesium metabolism for an individual (*11*). Adult males have a long equivalent biological half-time for cesium (105 days ± 25 days),[4] while the values for women (84 ± 28 days),[4] children and adolescents (57 ± 20 days),[4] and infants (19 ± 8 days),[4] are shorter (*10*). Women and children tend to have lower body concentrations of cesium-137 (^{137}Cs/K) than men consuming a similar diet because of their shorter equivalent biological half-times for cesium. This trend can be seen in our data on farms for which an entire family has been measured (figure 20).

A striking observation that one can make from figures 2 to 20 is that the cesium-137 to potassium ratios of the people in most cases were similar to the cesium-137 to potassium ratios in their dietary milk during the time when their cesium-137 contents were increasing. The people generally had a higher cesium-137 to potassium ratio than milk during the time when their cesium-137 contents were decreasing.

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[4] One-standard deviation.

We have shown in other studies (*11*) that for children and adults, body ^{137}Cs/K is about 2 to 4 times higher than the ^{137}Cs/K in their total dietary intake. During the increasing phase of this study, the ratios in people and milk were similar; this observation coincides with the expectation that food other than milk may have been the major source of potassium for these people but that their milk may have been a major source of cesium-137. With rapidly diminishing levels of cesium-137 in milk, human body burdens decrease less rapidly, not only because of the long cesium retention times in humans, but also because of the intake of processed foods (usually produced at earlier times when cesium-137 levels may have been higher) thus altering the relative contribution of cesium-137 from milk and non-milk foods in the diet. The ^{137}Cs/K in people averaged about 2.5 to 4 times that in their milk during the decreasing phase. Values for men were the highest, values for children were the lowest, and values for women were intermediate. This is a consequence of the differing cesium half-times for these groups.

Because of the dependence of body burden on cesium half-time, it is appropriate to relate the human data and milk data by a function that includes the cesium half-time of the individual as a factor. Assuming that a mildly perturbed, steady-state system can be treated as a first order, one compartment system, a computer program[5] was written which estimated the cesium half-time of a subject based on his serially-measured body burdens and the cesium-137 levels in the milk produced on the farm on which he resided. Figure 21 shows the shape of the month-by-month predicted body cesium-137 to potassium ratios calculated for one of these dairy farmers using the biological half-time obtained by this program and the assumption that the rate of cesium-137 intake is proportional to the milk cesium-137 content. The plotted points represent actual measurements. This farmer's calculated half-time of 105 days agrees well with the average cesium half-time measured for adult males of 105 ± 25 days (*10*). Similar data for a female child are shown in figure 22. Her calculated half-time of 60 days agrees well with the average value measured for children of 57 ± 20 days (*10*). The agreement between measured and predicted body burdens for the two subjects for whom this analysis has been made is surprisingly good.

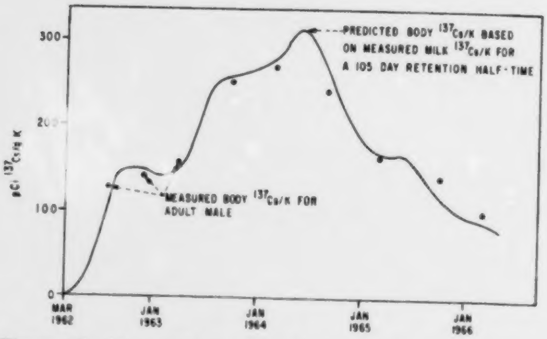

Figure 21. Comparison of measured ^{137}Cs/K ratios for male adult [(M 1935—2½) in figure 13] with predicted values based on a 105 day cesium half-time (calculated from milk and body concentration data)

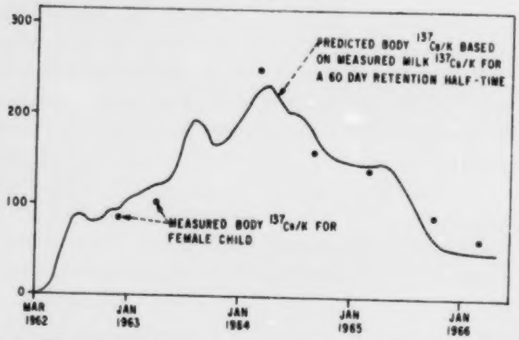

Figure 22. Comparison of measured ^{137}Cs/K ratios for female child [(F 1952—1¼) in figure 4] with predicted values based on a 60 day cesium half-time (calculated from milk and body concentration data)

An expanded analysis of the relationship between the cesium-137 content of milk and the cesium-137 content of humans consuming that milk via a transfer function that includes the individual cesium half-time and the individual milk consumption value as factors is planned for a future report.

Acknowledgements

The cooperation of the farm families that participated in this study was essential and is acknowl-

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[5] Details of the assumptions, concepts, and mathematics used for this computer program may be obtained from the authors upon request.

edged with thanks as is the continuous support of the U.S. Public Health Service, Bureau of Radiological Health (RH-30) during the entire period. Human whole-body counting and milk counting were done by B. W. Church, W. W. Wagner, R. L. Aamodt, A. B. Tueller, C. McBride Woodbury, and W. C. Knott.

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SECTION I. MILK AND FOOD

Milk Surveillance, June 1969

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be leased to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation and/or corrective public health action.

The Pasteurized Milk Network (PMN), sponsored by the Bureau of Radiological Health, Environmental Control Administration, and the Bureau of Compliance, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Public Health Service)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that occur in or are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents

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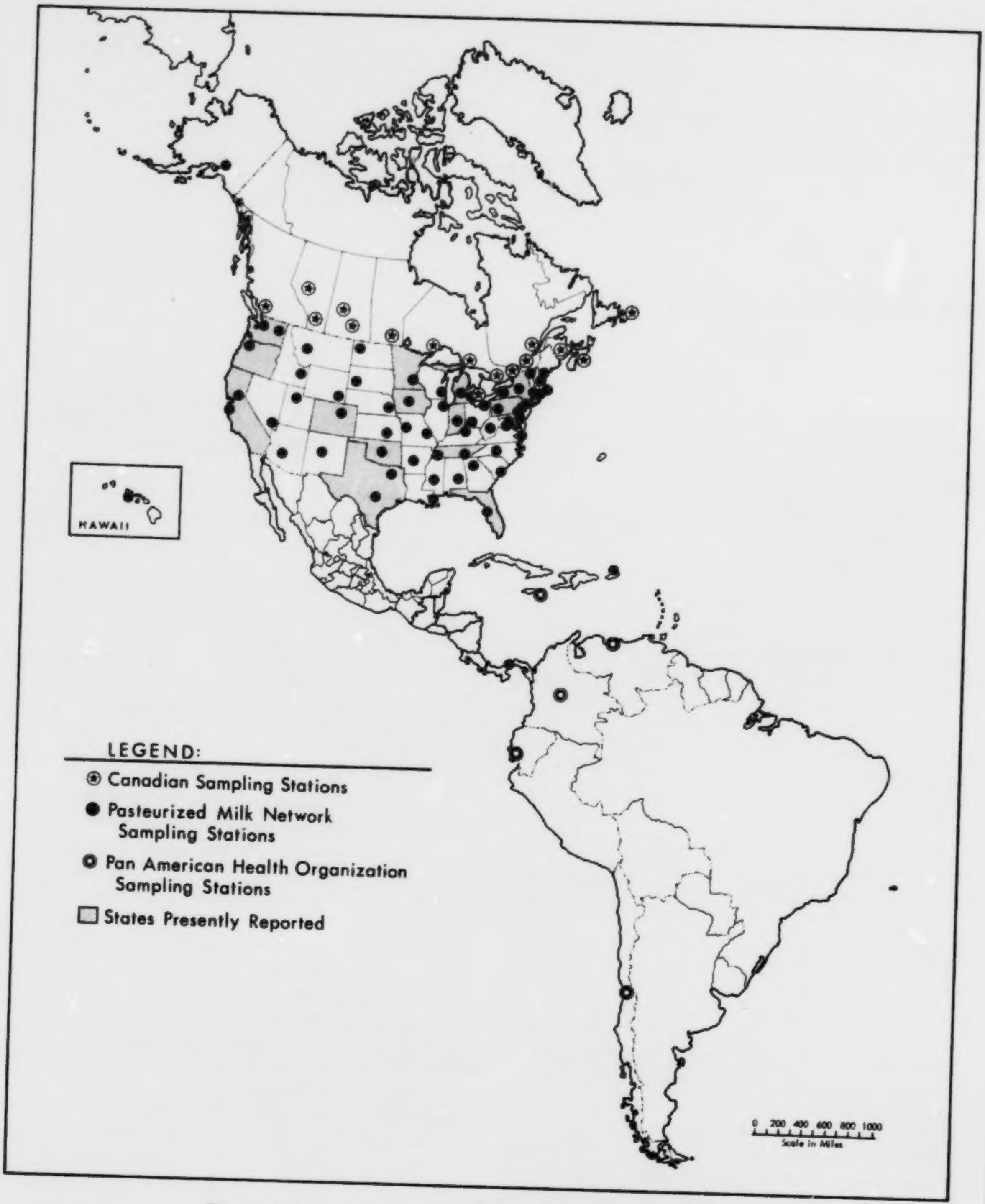
HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
⊙ Pan American Health Organization Sampling Stations
▢ States Presently Reported
0 200 400 600 800 1000
Scale in Miles

Figure 1. Milk sampling networks in the Western Hemisphere

of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variation, expressed in terms of 2-standard deviations, for these concentrations are 1.16 ± 0.08 g/liter and 1.51 ± 0.21 g/liter for calcium and potassium, respectively. These figures are averages of data from the PMN for the period, May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Bureau of Radiological Health conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted in December 1968, with 37 laboratories participating in an experiment on milk samples containing known concentrations of strontium-89, strontium-90, iodine-131 and cesium-137. Of the 19 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 18 participated in the experiment.

In general, the results for iodine-131 and cesium-137 are adequate but the results for strontium-89 and strontium-90 need improvement (*5*). Keeping these possible differences in mind, integration of the data from the various networks can be undertaken without introducing a serious error due to disagreement among the independently obtained data.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methodologies, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A recent article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data articles for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. The frequency of collection and analysis varies not only among the networks, but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short time periods and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of the radionuclide.

The data presentation also reflects whether raw or pasteurized milk was collected. A recent analysis (*7*) of raw and pasteurized milk samples collected during the period, January 1964 to June 1966, indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant. Particular attention was paid to strontium-90 and cesium-137 in that analysis.

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Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses experiments (*3*). The practical reporting level reflects additional analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical errors of precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter

For iodine-131, cesium-137, and barium-140 there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions is presented below. The function of the Council is to provide guidance to Federal agencies in the formulation of radiation standards.

Radiation Protection Guides (*8, 9*)

The Radiation Protection Guide (RPG) has been defined by the Federal Radiation Council (FRC) as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable. An RPG provides radiation protection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risk to the general public that might result from exposures from routine uses of ionizing radiation and the benefits from the activities causing the exposure.

Table 1 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable. A more detailed discussion of these values was presented earlier (*3*).

In the absence of specific dietary data one can use milk as the indicator food item for routine surveillance. Assuming a 1-liter per day intake of milk, one can utilize the graded approach of daily intake on the basis of radionuclide content in milk samples collected to represent general population consumption. Under these assumptions, the radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Table 1. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Radionuclide	Critical organ	RPG for individual in the general population (rad/yr)	RPG (rad/yr)	Guidance for suitable samples of exposed population group[a]			
				Corresponding continuous daily intake (pCi/day)	Range I[b] (pCi/day)	Range II[b] (pCi/day)	Range III[b] (pCi/day)
Strontium-89	Bone	[c] 1.5	0.5	[d] 2,000	0-200	200-2,000	2,000-20,000
	Bone marrow	[c] .5	.17				
Strontium-90	Bone	[c] 1.5	.5	[d] 200	0-20	20-200	200-2,000
	Bone marrow	[c] .5	.17				
Iodine-131	Thyroid	1.5	.5	100	0-10	10-100	100-1,000
Cesium-137[e]	Whole body	.5	.17	3,600	0-360	360-3,600	3,600-36,000

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[a] Suitable samples which represent the limiting conditions for this guidance are: strontium-89, strontium-90—general population; iodine-131—children 1 year of age; cesium-137—infants.

[b] Based on an average intake of 1 liter of milk per day.

[c] A dose of 1.5 rad/yr to the bone is estimated to result in a dose of 0.5 rad/yr to the bone marrow.

[d] For strontium-89 and strontium-90, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third the respective RPG.

[e] The guides expressed here were not given in the FRC reports, but were calculated using appropriate FRC recommendations.

Protective Action Guides (*10, 11*)

The Protective Action Guide (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the accidental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a 1 or 2-year period in a particular area would require special consideration. Protective actions are appropriate when the health benefits associated with the reduction in exposure to be achieved are sufficient to offset the undesirable features of the protective actions.

Table 2 presents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable. A more detailed discussion of these values was presented earlier (*3*). Also given in table 2 are milk concentrations for each of the radionuclides considered, in the absence of others, which if attained after an acute incident, would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentration from an idealized model for any acute deposition and the pasture-cow-milk-man pathway, as well as an estimate of the intake prior to reaching the

Table 2. Protective Action Guides—FRC recommendations and related information pertaining to environmental levels following an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Maximum concentration in milk for single nuclide that would result in PAG (pCi/liter)
Strontium-89	Bone marrow	10 in first yr; total dose not to exceed 15[a,b]	3 in first yr; total dose not to exceed 5[a,b]	[c] 1,110,000
Strontium-90	Bone marrow			[c] 51,000
Cesium-137	Whole body			[c] 720,000
Iodine-131	Thyroid	30	10	[d] 70,000

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[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.

[b] Total dose from strontium-89 and cesium-137 is the same as dose in first year; total dose from strontium-90 is 5 times strontium-90 dose in first year for children approximately 1 year of age.

[c] These values represent concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.

[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration observed in milk from an acute contaminating event. A maximum of 84,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered. Children, 1 year of age, are assumed to be the critical segment of the population.

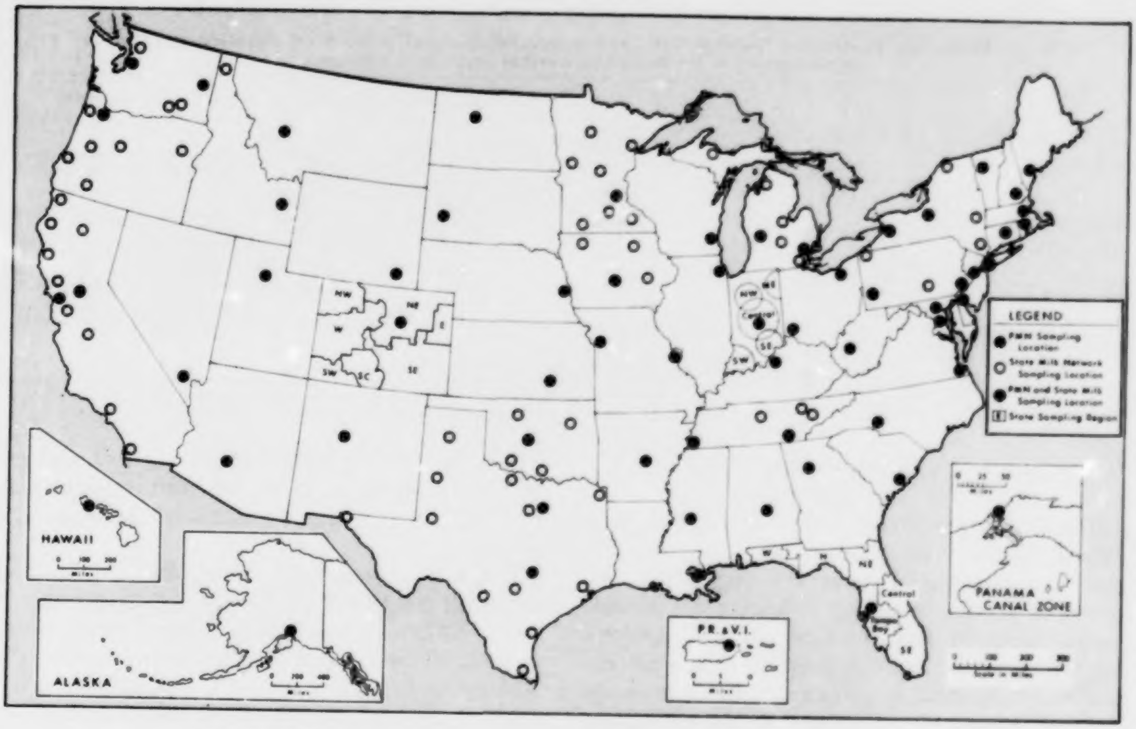

Figure 2. State and PMN milk sampling locations in the United States

maximum concentration. Therefore, these maximum concentrations are intended for use in estimating future intake on the basis of a few early samples rather than in retrospective manner.

Data reporting format

Table 3 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports*. The relationship between the PMN stations and State stations is shown in figure 2. The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12-monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 3, surveillance results are given for strontium-90, iodine-131, and cesium-137 for June 1969 and the 12-month period, July 1968 to June 1969. Except where noted the monthly average represents a single sample for the sampling station. Strontium-89 and barium-140 data have been omitted from table 3 since levels at the great majority of the stations for June 1969 were below the respective practical reporting levels. Table 4 gives monthly averages for those stations at which strontium-89 was detected.

Table 3. Concentration of radionuclides in milk for June 1969 and 12-month period, July 1968 through June 1969

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	7	6	0 (3)	0	2 (3)	11
Alaska:	Palmer[c]	P	4	8	0	0	0	12
Ariz:	Phoenix[c]	P	3	1	0 (4)	0	0 (4)	1
Ark:	Little Rock[c]	P	20	20	0 (4)	0	15 (4)	18
Calif:	Sacramento[c]	P	4	2	0 (5)	0	0 (5)	1
	San Francisco[c]	P	2	2	0 (4)	0	0 (4)	2
	Del Norte	P	21	20	0	0	21	21
	Fresno	P	0	0	0	0	0	3
	Humboldt	P	5	0	0	0	12	11
	Los Angeles	P	0	1	0	0	0	4
	Mendocino	P	3	3	0	0	0	3
	Sacramento	P	3	3	0	0	0	4
	San Diego	P	0	0	0	0	0	3
	Santa Clara	P	0	0	0	0	0	5
	Shasta	P	3	3	0	0	0	5
	Sonoma	P	3	2	0	0	0	3
Colo:	Denver[c]	P	5	5	0 (3)	0	4 (3)	4
	West	R	(d)		NS	(e)	NS	(e)
	Northeast	R	(d)		NS	(e)	NS	(e)
	East	R	(d)		NS	(e)	NS	(e)
	Southeast	R	(d)		NS	(e)	NS	(e)
	South Central	R	(d)		NS	(e)	NS	(e)
	Southwest	R	(d)		(e)	(e)	(e)	(e)
	Northwest	R	(d)		NS	(e)	NS	(e)
Conn:	Hartford[c]	P	8	9	0 (4)	0	13 (4)	12
	Central	P	8	7	0 (4)	0	10 (4)	10
Del:	Wilmington[c]	P	NA		0 (2)	0	7 (2)	7
D.C.:	Washington[c]	P	6	8	0 (3)	0	6 (3)	4
Fla:	Tampa[c]	P	4	8	0 (3)	0	61 (3)	62
	West	R	11	11	7	1	18	24
	North	R	22	14	0	0	31	36
	Northeast	R	7	9	0	0	76	72
	Central	R	NA	8	0	1	72	75
	Tampa Bay area	R	9	8	0	0	50	63
	Southeast	R	NA	9	0	0	126	111
Ga:	Atlanta[c]	P	10	12	0 (3)	0	21 (3)	19
Hawaii:	Honolulu[c]	P	3	4	0 (4)	0	0 (4)	1
Idaho:	Idaho Falls[c]	P	5	5	0 (5)	0	5 (5)	8
Ill:	Chicago[c]	P	7	8	0 (5)	0	11 (5)	11
Ind:	Indianapolis[c]	P	9	8	0 (5)	0	4 (5)	6
	Northeast	P	13	10	0	0	0	10
	Southeast	P	7	9	0	0	10	10
	Central	P	10	9	0	0	10	11
	Southwest	P	10	8	0	0	5	11
	Northwest	P	12	11	0	0	20	12
Iowa:	Des Moines[c]	P	0	5	0 (4)	0	3 (4)	3
	Iowa City	P	NS		NS		NS	
	Des Moines	P	NS		NS		NS	
	Spencer	P	NS		NS		NS	
	Fredericksburg	P	NS		NS		NS	
Kans:	Wichita[c]	P	9	7	0 (5)	0	3 (5)	3
Ky:	Louisville[c]	P	10	11	0 (3)	0	10 (3)	7
La:	New Orleans[c]	P	16	18	0 (3)	0	21 (3)	22
Maine:	Portland[c]	P	11	12	0	1	26	25
Md:	Baltimore[c]	P	9	9	0 (5)	0	4 (5)	7
Mass:	Boston[c]	P	11	11	0 (3)	0	19 (3)	22
Mich:	Detroit[c]	P	8	9	0 (5)	0	7 (5)	10
	Grand Rapids[c]	P	13	10	0 (5)	0	9 (5)	14
	Bay City	P	NA	5	0	0	16	11
	Charlevoix	P	NA	9	(e)	(e)	18 (5)	13
	Detroit	P	NA	5	(e)	(e)	3 (5)	4
	Grand Rapids	P	NA	6	(e)	(e)	13 (5)	10
	Lansing	P	NA	5	(e)	(e)	11 (3)	5
	Marquette	P	NA	9	(e)	(e)	27 (2)	29
	Monroe	P	NA	3	(e)	1	0 (2)	1
	South Haven	P	NS	7	NS	(e)	NS	8
Minn:	Minneapolis[c]	P	14	12	0 (4)	0	9 (4)	13
	Bemidji	P	16	16	0	0	27	22
	Mankato	P	10	7	0	0	8	0
	Rochester	P	7	8	0	0	13	0
	Duluth	P	20	20	0	0	24	27
	Worthington	P	10	7	0	0	0	0
	Minneapolis	P	14	13	0	0	11	13
	Fergus Falls	P	11	10	0	0	11	0
	Little Falls	P	10	10	0	0	14	16
Miss:	Jackson[c]	P	13	15	0 (4)	1	15 (4)	16
Mo:	Kansas City[c]	P	9	7	0 (4)	0	3 (4)	2
	St. Louis[c]	P	9	9	0 (4)	0	3 (4)	5
Mont:	Helena[c]	P	6	5	0 (3)	0	7 (3)	8
Nebr:	Omaha[c]	P	6	6	0 (3)	0	1 (3)	3
Nev:	Las Vegas[c]	P	0	1	0 (4)	0	0 (4)	1
N.H.:	Manchester[c]	P	11	11	0 (4)	0	21 (4)	30
N.J:	Trenton[c]	P	10	9	0 (4)	0	6 (4)	9
N. Mex:	Albuquerque[c]	P	2	2	0 (5)	0	0 (5)	1

See footnotes at end of table.

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Table 3. Concentration of radionuclide in milk for June 1969 and 12-month period, July 1968 through June 1969—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—Contiaued								
N.Y:	Buffalo[c]	P	8	7	0 (4)	0	10 (4)	10
	New York City[c]	P	12	11	0 (5)	0	14 (5)	14
	Syracuse[c]	P	7	8	0 (4)	0	8 (4)	8
	Albany	P	8	8	0 (5)	0	(e) (5)	(e)
	Buffalo	P	(e)	(e)	0	0	(e)	(e)
	Massena	P	11	11	0 (3)	0	26 (3)	(e)
	Newburg	P	(e)	11	0	0	(e)	(e)
	New York City	P	11	12	0 (4)	0	(e) (4)	(e)
	Syracuse	P	6	8	0	0	(e)	(e)
N.C:	Charlotte[c]	P	18	15	0 (4)	0	17 (4)	12
N. Dak:	Minot[c]	P	9	11	0 (5)	0	10 (5)	12
Ohio:	Cincinnati[c]	P	9	8	0 (4)	0	1 (4)	3
	Cleveland[c]	P	9	9	0 (4)	0	8 (4)	8
Okla:	Oklahoma City[c]	P	11	9	0 (4)	0	16 (4)	8
	Oklahoma City	P	NS		NS		NS	
	Enid	P	NS		NS		NS	
	Tulsa	P	NS		NS		NS	
	Lawton	P	NS		NS		NS	
	Ardmore	P	NS		NS		NS	
Ore:	Portland[c]	P	7	8	0 (4)	0	8 (4)	10
	Baker	P	NA	3	(e)	(e)	(e)	8
	Coos Bay	P	NA	8	(e)	(e)	23	15
	Eugene	P	NA	4	(e)	(e)	(e)	12
	Medford	P	NA	2	(e)	(e)	15	14
	Portland composite	P	NA	5	(e)	(e)	(e) (4)	5
	Portland local	P	NA	5	(e)	(e)	19	6
	Redmond	P	NA	2	(e)	(e)	(e)	5
	Tillamook	P	NA	8	(e)	(e)	(e)	22
Pa:	Philadelphia[c]	P	9	9	0 (4)	0	4 (4)	6
	Pittsburgh[c]	P	13	12	0 (4)	0	9 (4)	9
	Dauphin	P	7	7	NA	0	NA	19
	Erie	P	11	11	NA	0	NA	22
	Philadelphia	P	9	9	NA	0	NA	18
	Pittsburgh	P	7	11	NA	0	NA	16
R.I:	Providence[c]	P	12	10	0 (4)	0	18 (4)	18
S.C:	Charleston[c]	P	9	12	0 (3)	0	23 (3)	23
S. Dak:	Rapid City[c]	P	10	7	0 (5)	0	5 (5)	8
Tenn:	Chattanooga[c]	P	11	12	0 (4)	0	22 (4)	13
	Memphis[c]	P	10	10	0 (3)	0	4 (3)	5
	Chattanooga	P	8	11	3 (5)	0	20	16
	Clinton	P	31	14	0 (2)	0	19	17
	Knoxville	P	16	10	0 (3)	1	14	10
	Nashville	P	6	9	0 (3)	0	15	7
Tex:	Austin[c]	P	0	2	0 (2)	0	6 (2)	3
	Dallas[c]	P	8	7	0 (4)	0	14 (4)	7
	Amarillo	R	NS		NS		NS	
	Corpus Christi	R	NS		NS		NS	
	El Paso	R	NS		NS		NS	
	Fort Worth	R	NS		NS		NS	
	Harlingen	R	NS		NS		NS	
	Houston	R	NS		NS		NS	
	Lubbock	R	NS		NS		NS	
	Midland	R	NS		NS		NS	
	San Antonio	R	NS		NS		NS	
	Texarkana	R	NS		NS		NS	
	Uvalde	R	NS		NS		NS	
	Wichita Falls	R	NS		NS		NS	
Utah:	Salt Lake City[c]	P	0	5	0 (4)	0	0 (4)	9
Vt:	Burlington[c]	P	9	9	0 (4)	0	14 (4)	11
Va:	Norfolk[c]	P	9	10	0 (3)	0	3 (3)	8
Wash:	Seattle[c]	P	9	9	0 (4)	0	19 (4)	18
	Spokane[c]	P	3	6	0 (4)	0	9 (4)	7
	Benton County	R	NS	1	NS	0	NS	6
	Franklin County	R	3	1	0	0	0	0
	Sandpoint, Idaho	R	15	10	0	0	32	25
	Skagit County	R	10	6	0	0	15	11
W. Va:	Charleston[c]	P	NA	10	0 (2)	0	5 (2)	8
Wisc:	Milwaukee[c]	P	7	7	0 (4)	0	12 (4)	12
Wyo:	Laramie[c]	P	4	4	0 (4)	0	1 (4)	10
CANADA:								
Alberta:	Calgary	P	7	8	(d)		11	16
	Edmonton	P	4	7	(d)		10	17
British Columbia:	Vancouver	P	14	13	(d)		36	42
Manitoba:	Winnipeg	P	8	8	(d)		18	24
New Brunswick:	Fredericton	P	11	14	(d)		22	21
Newfoundland:	St. Johns	P	17	19	(d)		34	38
Nova Scotia:	Halifax	P	11	11	(d)		17	20
Ontario:	Ft. William	P	15	16	(d)		22	32
	Ottawa	P	10	9	(d)		11	17
	Sault Ste. Marie	P	16	15	(d)		29	33

See footnotes at end of table.

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Table 3. Concentration of radionuclides in milk for June 1969 and 12-month period, July 1968 through June 1969—Continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average	Monthly average [b]	12-month average
CANADA—Continued								
Ontario:	Toronto	P	5	5	(d)		6	13
	Windsor	P	7	6	(d)		9	13
Quebec:	Montreal	P	10	8	(d)		14	19
	Quebec	P	12	11	(d)		23	27
Saskatchewan:	Regina	P	6	7	(d)		9	16
	Saskatoon	P	4	9	(d)		9	17
CENTRAL AND SOUTH AMERICA:								
Columbia:	Bogota	P	NS		NS		NS	
Chile:	Santiago	P	0	0	0	0	0	0
Ecuador:	Guayaquil	P	0	0	0	0	0	0
Jamaica:	Montego Bay	P	0	5	0	0	175	100
Venezuela:	Caracas	P	NS		NS		NS	
Canal Zone:	Cristobal[e]	P	0	2	0 (4)	1	4 (4)	13
Puerto Rico:	San Juan[e]	P	4	4	0 (4)	0	5 (4)	7
PMN network average			8	8	0	0	9	10

[a] P, pasteurized milk; R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] PHS Pasteurized Milk Network station. All other sampling locations are part of the State or national network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for these networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado—25 pCi/liter
Michigan—14 pCi/liter
Oregon—15 pCi liter

Cesium-137: Colorado—25 pCi/liter
New York—20 pCi/liter
Oregon—15 pCi/liter

Strontium-90: New York—3 pCi/liter

[f] This entry gives the average radionuclide concentrations for the PHS pasteurized milk network stations denoted by footnote [c].

NA, no analysis.

NS, no sample collected.

Iodine-131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council (table 1), levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting level for iodine-131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium-90 monthly averages ranged from 0 to 31 pCi/liter in the United States for the month of June 1969 and the highest 12-month average was 20 pCi/liter at Little Rock Ark., Del Norte, Calif., and, Duluth, Minn., representing 10.0 percent of the Federal Radiation Council radiation protection guide (table 1). Cesium-137 monthly averages ranged from 0 to 126 pCi/liter in the United States for the month of June 1969 and the highest 12-month average was 111 pCi/liter at southeast Florida representing 3.1 percent of the value presented in this report using the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*12*) and Jamaica. Iodine results for individual samples were all below the practical reporting level, except Chattanooga, Tenn.(State), 3 pCi/liter, 5 samples.

Table 4. Strontium-89 in milk, June 1969

Sampling location		Strontium-89 (pCi/liter)
D.C:	Washington	7 (2)
Ky:	Louisville	7 (2)
La:	New Orleans	10 (2)
Miss:	Jackson	7 (2)
Mo:	Kansas City	9
N. Dak:	Minot	7
Okla:	Oklahoma City	8 (2)
Ore:	Portland	6
S. Dak:	Rapid City	9
Tenn:	Chattanooga	8 (2)
	Memphis	8 (2)
Tex:	Austin	5 (3)
	Dallas	8 (3)
Wash:	Seattle	11
	Spokane	9

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California State Department of Health

Radiological Health Section
Division of Air, Occupational, and Radiation Hygiene
Colorado State Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Division of Radiological Health
Bureau of Preventable Diseases
Florida State Board of Health

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiological Health Service
Division of Occupational Health
Michigan Department of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Health
Division of Environmental Health Services
New York State Department of Health

Division of Occupational and Radiological Health
Environmental Health Services
Oklahoma State Department of Health

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

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Radiostrontium in Milk[1], January-December 1968

Health and Safety Laboratory
U.S. Atomic Energy Commission

In 1954, the Health and Safety Laboratory began monitoring strontium-90 in liquid whole milk in New York to estimate the dietary contribution from ingestion of radiostrontium in milk. Subsequently, powdered milk monitoring was initiated at Perry, N.Y. (1954), and at Mandan, N. Dak. (1955). Liquid whole milk monitoring was started in Honolulu, Hawaii, in August 1959. Sampling was terminated at Mandan, N. Dak., and Honolulu, Hawaii at the end of June 1965.

The New York City sample is a monthly composite of pasteurized milk purchased daily in quart containers at retail stores. Five large dairies are represented in the sample. The Perry samples are monthly composites of powdered whole milk for human consumption collected weekly in 5-pound lots from plants in the city. The strontium-90 to calcium ratios in whole milk are presented in table 1.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July–December 1966	September 1967
January–December 1967	August 1968

Table 1. Strontium-90 to calcium ratios in milk, January-December 1968

Sampling location	Strontium-90 to calcium ratio (pCi/g)											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
New York, N.Y. (liquid whole milk)	7.0	7.6	7.4	7.8	7.8	12.7	11.6	10.2	9.0	8.6	9.4	8.5
Perry, N.Y. (powdered whole milk)	6.2	5.7	6.7	5.7	6.9	9.8	8.8	8.9	7.4	7.3	6.8	6.3

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[1] Data summarized from "Fallout Program Quarterly Summary Report," HASL-207 App., available from Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Va. 22151.

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows.

Program	Period reported	Issue
California Diet Study	November 1967–September 1968	May 1969
Connecticut Diet Study	January–June 1968	November 1968
Tri-City Diet, *HASL*	January–June 1968	April 1969

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1. Radionuclides in Institutional Diet Samples January–March 1969 and Annual Summary 1968

Bureau of Radiological Health and
Bureau of Compliance, Food and Drug Administration

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiological surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is administered by the Bureau of Radiological Health with the assistance of the Bureau of Compliance, Food and Drug Administration.

The program was designed to provide estimates of the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program was conducted at eight institutions; as of January 1965, its scope had increased to boarding schools or institutions in 50 municipalities. These institutions ranged from financially well-to-do boarding schools to orphanages with severe economic limitations.

Subsequent experience with the diets of school children of various ages indicated that the number of institutions sampled could be selectively reduced. As of July 1965, 21 basic institutions and eight auxiliary institutions distributed geographically as shown in figure 1, were being sampled. Previous results showed that the daily dietary intake of teenage girls and children from 9 to 12 years of age were comparable, while teenage boys consumed 20 percent more food per day (*1*, *2*). Consequently, estimates for boys and/or girls can be calculated on the basis of the dietary intakes of children.

In general, the sampling procedure is the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week, (21 meals plus soft drinks, candy bars, or other in-between snacks) obtained by duplicating the meals of a different individual each day. Drinking water, not included in the samples, is also sampled periodically. Each daily sample is kept frozen

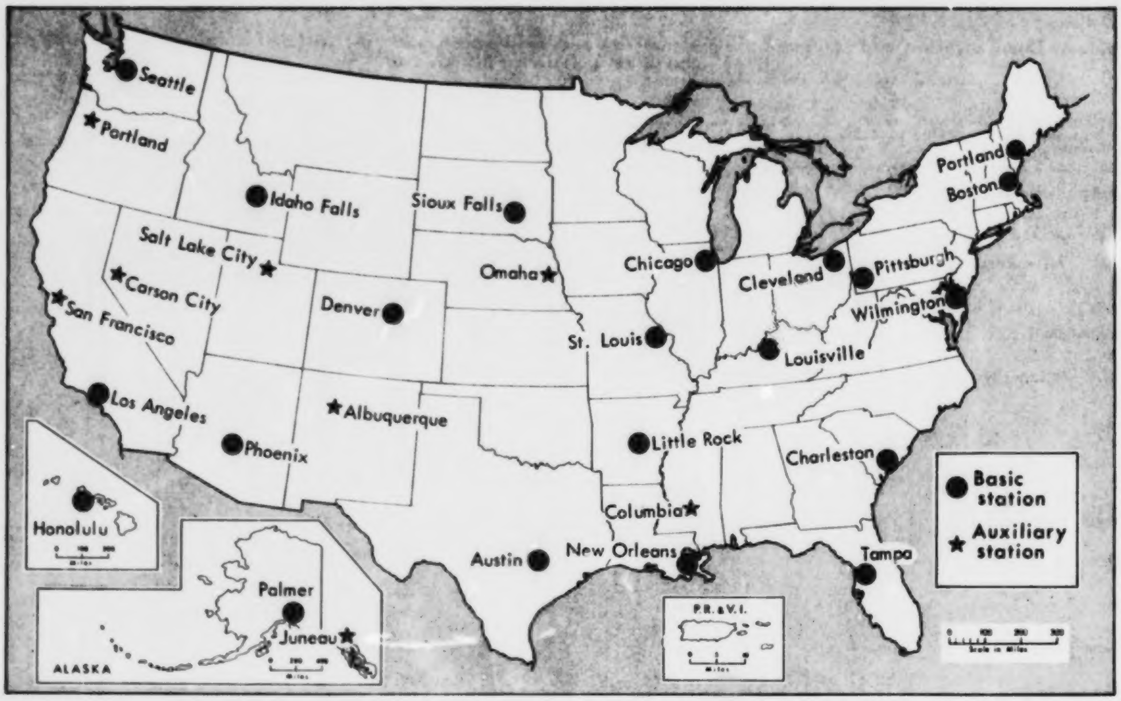
Seattle
Portland
Idaho Falls
Sioux Falls
Salt Lake City
Carson City
San Francisco
Denver
Omaha
Chicago
Cleveland
Pittsburgh
Wilmington
Portland
Boston
St. Louis
Louisville
Los Angeles
Albuquerque
Phoenix
Little Rock
Charleston
Columbia
New Orleans
Austin
Tampa
Honolulu
Palmer
Juneau
ALASKA
P.R. & V.I.
Basic station
Auxiliary station

Figure 1. Institutional diet sampling locations as of March 1969

until the end of the collection period and is then packed in dry ice and shipped by air express to either the southwestern Radiological Health Laboratory, Las Vegas, Nev; the Southeastern Radiological Health Laboratory, Montgomery, Ala; or the Northeastern Radiological Health Laboratory, Winchester, Mass. A detailed description of sampling and analytical procedures was presented earlier (*3*).

Results

Table 1 presents the analytical results for institutional diet samples collected from January through March 1969, for children 9 to 12 years of age. The stable elements, calcium and potassium, are reported in g/kg of diet, and the radionuclide concentrations of these samples, reported in pCi/kg of diet, are corrected for radioactive decay to the midpoint of the sample collection period, where applicable. Dietary intakes, in g/day or pCi/day, were obtained by multiplying the food consumption rate in kg/day by the appropriate concentration values. The average food consumption rate during this period was 1.90 kg/day compared to the network average of 1.87 kg/day observed from 1961 through 1968.

Strontium-90 dietary intake during this period averaged 15 pCi/day. This result falls within Range I as defined by the Federal Radiation Council (*4*). Cesium-137 intakes averaged 21 pCi/day during this period. Strontium-89, barium-140, and iodine-131 concentrations were generally below detectable levels.

All concentrations that are less than or equal to the appropriate minimum detectable level will be reported as zero. The minimum detectable concentration is defined as the measured concentration equal to the 2-standard deviation analytical error. Accordingly, the minimum detectable limits are as follows:

Table 1. Concentration and intake of stable elements and radionuclides in Institutional total diets of children (9–12 years of age), January–March 1969

Location of Institution	Month (1969)	Total weight (kg/day)	Calcium (g/kg)	Calcium (g/day)	Potassium (g/kg)	Potassium (g/day)	^{89}Sr (pCi/kg)	^{89}Sr (pCi/day)	^{90}Sr (pCi/kg)	^{90}Sr (pCi/day)	^{137}Cs (pCi/kg)	^{137}Cs (pCi/day)	^{226}Ra (pCi/kg)	^{226}Ra (pCi/day)
Alaska: Palmer	Jan	1.85	0.56	1.04	1.2	2.2	0	0	5	8	0	0	0.3	0.6
	Feb	[a] 1.32	.63	.83	1.5	2.0	0	0	2	3	0	0	.6	.8
	Mar	1.17	.71	.83	1.6	1.9	0	0	10	12	12	14	.6	.7
Ariz: Phoenix[b]	Jan	1.68	.97	1.63	2.1	3.5	6	10	5	9	0	0	.4	.7
	Mar	1.94	.56	1.09	1.5	3.0	0	0	4	7	0	0	.5	1.0
Ark: Little Rock	Jan	1.56	.36	.56	1.2	1.9	NA	NA	6	10	0	0	.6	.9
	Feb	1.41	.58	.82	1.6	2.3	NA	NA	14	20	16	23	.7	1.0
	Mar	1.40	.45	.63	1.3	1.9	NA	NA	8	11	0	0	.3	.4
Calif: Los Angeles[c]	Feb	[a] 1.50	.35	.53	1.0	1.6	0	0	0	0	0	0	.4	.6
	Mar	[a] 2.22	.57	1.27	1.5	3.2	0	0	3	7	0	0	.4	.9
Colo: Denver	Jan	[a] 2.19	.93	2.04	1.7	3.8	0	0	8	17	0	0	.5	1.1
	Feb	[a] 2.17	.79	1.71	1.6	3.5	0	0	5	11	0	0	.6	1.3
	Mar	[a] 2.44	.74	1.81	1.5	3.7	0	0	4	10	0	0	.4	1.1
Del: Wilmington	Jan	2.15	.72	1.55	2.0	4.3	NA	NA	8	17	0	0	.3	.6
	Feb	2.17	.62	1.35	1.8	3.9	NA	NA	6	13	12	26	.7	1.5
	Mar	2.33	.61	1.42	1.5	3.5	NA	NA	6	14	11	26	.6	1.4
Fla: Tampa	Jan	1.39	.52	.72	1.5	2.1	NA	NA	10	13	17	24	.9	1.3
	Feb	[a] 1.18	.67	.79	1.6	1.8	NA	NA	8	9	24	28	.6	.7
	Mar	[a] 1.20	.65	.78	1.4	1.7	NA	NA	8	10	28	34	.7	.8
Hawaii: Honolulu	Jan	[a] 2.41	NA	NA	1.4	4.1	0	0	5	12	16	39	.4	1.0
	Feb	2.86	NA	NA	1.4	4.0	0	0	4	12	23	66	.5	1.4
	Mar	2.86	NA	NA	1.4	4.0	0	0	4	11	11	31	.6	1.7
Ill: Chicago[d]														
Idaho: Idaho Falls	Jan	[a] 1.93	1.00	1.93	2.0	3.9	0	0	8	15	19	37	.6	1.2
	Feb	2.17	1.54	3.34	1.6	3.5	0	0	13	28	16	35	.7	1.5
	Mar	2.04	.75	1.53	1.7	3.5	0	0	6	12	15	31	.4	.8
Ky: Louisville	Jan	2.23	.70	1.56	1.6	3.7	NA	NA	8	17	0	0	1.1	2.5
	Feb	1.64	.75	1.23	1.6	2.7	NA	NA	10	16	12	20	1.2	2.0
	Mar	[a] 1.63	.66	1.08	1.5	2.5	NA	NA	6	10	0	0	.8	1.3
La: New Orleans	Jan	1.60	.26	.42	1.3	2.1	0	0	7	11	0	0	.5	.8
	Feb	2.02	.51	1.03	1.7	3.4	0	0	9	18	11	22	.4	.8
	Mar	2.11	.56	1.18	1.7	3.5	0	0	9	19	12	25	.3	.6
Maine: Portland	Jan	1.77	.83	1.47	2.3	4.0	NA	NA	12	21	23	41	.7	1.2
	Feb	1.81	.94	1.70	2.1	3.8	NA	NA	11	20	20	36	.7	1.3
	Mar	1.78	.78	1.39	1.7	3.0	NA	NA	12	21	30	53	.7	1.2
Mass: Boston	Jan	2.26	.60	1.36	2.1	4.7	NA	NA	8	18	16	36	.5	1.1
	Feb	1.85	.72	1.33	1.7	3.1	0	0	10	19	22	41	.5	.9
	Mar	2.27	.59	1.34	1.9	4.3	0	0	8	18	18	41	.6	1.4
Mo: St. Louis	Jan	[a] 2.60	1.00	2.60	2.1	5.5	NA	NA	7	18	0	0	1.0	2.6
	Feb	[a] 1.98	1.09	2.16	1.9	3.8	NA	NA	8	16	17	34	.6	1.2
	Mar	[a] 2.54	.94	2.39	1.6	4.1	NA	NA	9	23	13	33	.9	2.3
Ohio: Cleveland	Jan	1.58	.63	1.00	2.0	3.1	NA	NA	8	13	0	0	.6	.9
	Feb	1.71	1.01	1.73	1.9	3.2	NA	NA	13	22	0	0	.6	1.0
	Mar	1.66	.65	1.08	1.6	2.7	NA	NA	5	8	0	0	.5	.8
Pa: Pittsburgh[e]	Jan	2.31	.57	1.32	1.7	3.8	NA	NA	8	18	0	0	1.1	2.5
	Feb	2.29	.53	1.21	1.5	3.4	NA	NA	7	16	12	27	.5	1.1
	Mar	2.33	.53	1.23	1.5	3.5	NA	NA	6	14	14	33	.5	1.2
S.C: Charleston	Jan	1.86	.70	1.30	1.6	3.0	0	0	9	17	17	32	.6	1.1
	Feb	2.18	.73	1.59	1.4	3.0	0	0	11	25	12	26	.6	1.3
	Mar	1.30	.72	0.94	1.4	1.8	0	0	9	12	16	21	.9	1.2
S.Dak: Sioux Falls	Jan	[a] 1.43	.67	0.96	1.7	2.5	NA	NA	8	11	0	0	.8	1.1
	Feb	[a] 1.46	.67	0.98	1.4	2.0	NA	NA	6	9	0	0	.7	1.0
	Mar	[a] 1.83	.59	1.08	1.6	2.9	NA	NA	6	11	14	26	.8	1.5
Tex: Austin	Jan	[a] 1.88	.84	1.58	1.7	3.3	NA	NA	5	9	0	0	.4	.8
	Feb	[a] 2.02	.80	1.62	1.7	3.4	NA	NA	6	12	0	0	.4	.8
	Mar	[a] 1.93	.76	1.47	1.4	2.7	NA	NA	4	8	0	0	.5	1.0
Wash: Seattle	Jan	[a] 2.00	.60	1.20	1.3	2.6	0	0	7	13	23	46	.5	1.0
	Feb	[a] 1.93	.90	1.74	1.6	3.1	0	0	8	16	0	0	.7	1.4
	Mar	[a] 1.81	.71	1.29	1.4	2.6	0	0	5	9	14	25	.5	.9
Institutional average	Jan	1.90	0.62	1.15	1.7	3.3	2	3	7	13	6	13	0.6	1.2
	Feb	1.99	0.71	1.33	1.7	3.3	0	0	10	18	14	29	0.6	1.2
	Mar	1.92	0.62	1.11	1.6	3.0	0	0	7	13	11	22	0.6	1.1

[a] Since food samples were collected from two or more children who were not between the ages of 9 to 12, data for this month were not used in institutional average.

[b] The samples for Phoenix, Ariz. were not collected for the month of February.

[c] Sample for January in Los Angeles, Calif., area was not collected due to flooding.

[d] Samples were not collected from the Chicago, Ill. area during this period.

[e] Iodine-131 was reported in the sample for February for Pittsburgh: 12 pCi/kg and 27 pCi/day.

NA, no analysis.

Note: Iodine-131 and barium-140 were not detectable at most stations during the first quarter of 1969 therefore no provision was made for the nuclides in the table except the above.

Strontium-89	5 pCi/kg
Strontium-90	2 pCi/kg
Iodine-131	10 pCi/kg
Cesium-137	10 pCi/kg
Barium-140	10 pCi/kg
Radium-226	0.1 pCi/kg

Data from eight auxiliary stations are included in a separate table for general information. This is presented in table 2. These stations do not meet the criterion that the majority of the samples are collected from children who range in age from 9 to 12 years. In order to supplement the existing

Table 2. Concentration and intake of stable elements and radionuclides in Institutional total diets of individuals (auxiliary stations), January–March 1969

Location of Institution	Month (1969)	Total weight (kg/day)	Calcium		Potassium		^{89}Sr		^{90}Sr		^{137}Cs		^{226}Ra	
			(g/kg)	(g/day)	(g/kg)	(g/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)
Alaska: Juneau	Jan	1.34	0.63	0.84	1.4	1.8	0	0	8	11	12	16	0.3	0.4
	Feb	1.14	.40	.46	1.2	1.4	0	0	6	7	0	0	.3	.3
	Mar	1.60	.59	.94	1.2	2.0	0	0	9	14	0	0	.5	.8
Calif: San Francisco	Jan	2.39	.47	1.12	1.5	3.7	0	0	4	9	0	0	.2	.5
	Feb	2.36	.47	1.11	1.5	3.5	0	0	0	0	0	0	.5	1.2
	Mar	1.63	.42	.68	1.3	2.0	0	0	4	6	0	0	.5	.8
Miss: Columbia	Jan	2.24	1.10	2.46	1.5	3.4	NA	NA	12	27	12	27	.7	1.6
	Feb	2.07	.93	1.93	1.5	3.1	NA	NA	9	19	19	39	.5	1.0
	Mar	1.88	.88	1.65	1.5	2.9	NA	NA	8	15	12	23	.6	1.1
Nev: Carson City	Jan	1.80	1.02	1.84	1.8	3.3	0	0	4	7	12	22	.6	1.1
	Feb	1.47	.63	.93	1.5	2.2	0	0	0	0	0	0	.4	.6
	Mar	1.40	.68	.95	1.3	1.8	0	0	4	5	0	0	.6	.8
N. Mex: Albuquerque	Jan	2.57	.78	2.00	1.8	4.5	NA	NA	5	12	0	0	.4	1.0
	Feb	2.31	.83	1.92	1.4	3.2	NA	NA	3	6	0	0	.4	.9
	Mar	2.30	.76	1.75	1.4	3.1	NA	NA	4	8	0	0	.4	.9
Ore: Portland	Jan	1.56	.53	.83	1.8	2.9	8	12	8	12	0	0	.5	.8
	Feb	1.73	.56	.97	1.9	3.3	0	0	2	4	0	0	.4	.7
	Mar	1.72	.57	.98	1.7	2.9	0	0	3	6	0	0	.6	1.0
Utah: Salt Lake City	Jan	1.86	.53	.99	1.3	2.4	0	0	3	5	0	0	.3	.6
	Feb	1.66	.55	.91	1.2	1.9	0	0	2	4	0	0	.3	.5
	Mar	1.98	.44	.87	1.1	2.1	0	0	3	7	0	0	.5	1.0
Institutional average	Jan	1.97	0.72	1.44	1.6	3.1	2	2	6	12	5	9	0.4	0.8
	Feb	1.82	0.62	1.17	1.5	2.7	0	0	3	6	3	6	0.4	0.7
	Mar	1.79	0.62	1.12	1.3	2.4	0	0	5	9	2	3	0.5	0.9

NA, no analysis.

Table 3. 1968 annual average concentration and intake of stable elements and radionuclides in Institutional total diets of children (9–12 years of age)

Location of Institution		Total weight (kg/day)	Calcium		Potassium		^{90}Sr		^{137}Cs		^{226}Ra	
			(g/kg)	(g/day)	(g/kg)	(g/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)
Alaska:	Palmer	1.60	0.6	0.9	1.4	2.2	8	13	17	26	0.5	0.8
Ariz:	Phoenix	2.00	.6	1.2	1.3	2.6	4	9	4	8	.5	1.0
Ark:	Little Rock	1.67	.5	.9	1.5	2.1	10	17	6	10	.5	.8
Calif:	Los Angeles	1.64	.5	.8	1.3	2.0	4	7	2	4	.5	.9
Colo:	Denver	2.33	.7	1.6	1.5	3.4	6	13	9	21	.5	1.1
Del:	Wilmington	2.13	.7	1.4	1.6	3.5	8	17	7	16	.7	1.5
Fla:	Tampa	1.77	.5	1.0	1.7	3.0	8	12	32	57	.6	1.1
Hawaii:	Honolulu	2.30	.5	1.1	1.5	3.1	3	7	14	33	.4	1.0
Idaho:	Idaho Falls[a]	2.03	1.1	2.2	1.8	3.2	9	19	15	20	.5	1.0
Ill:	Chicago[b]	1.49	.7	1.1	1.6	2.4	6	10	16	24	.7	1.1
Ky:	Louisville	1.45	.6	.9	1.6	2.3	9	12	2	4	.7	1.0
La:	New Orleans	1.82	.6	1.1	1.6	3.0	11	21	15	28	.4	.8
Maine:	Portland	1.65	.8	1.3	1.6	2.7	13	21	25	41	.7	1.2
Mass:	Boston	1.79	.6	1.2	1.5	2.7	8	14	17	40	.6	1.0
Mo:	St. Louis	2.52	1.0	2.6	1.7	4.2	10	24	12	30	.7	1.9
Ohio:	Cleveland	1.48	.7	1.0	1.7	2.4	7	11	14	22	.7	1.0
Pa:	Pittsburgh	2.23	.6	1.2	1.5	3.2	8	18	10	22	.7	1.6
S.C:	Charleston	1.59	.7	1.1	1.5	2.3	10	15	20	31	.7	1.2
S.Dak:	Sioux Falls	1.41	.8	1.1	1.5	2.1	8	11	11	16	1.0	1.4
Tex:	Austin	1.80	.7	1.2	1.5	2.7	5	8	3	6	.4	.8
Wash:	Seattle[a]	1.93	.6	1.1	1.6	3.0	6	11	11	20	.5	1.0
Institutional average		1.83	0.7	1.2	1.5	2.7	8	14	12	23	0.6	1.1

[a] This data was not included in the institutional average since all children were not between 9 to 12 years of age.
[b] This data only includes samples collected during the first 7 months of the year due to the termination of sampling at this location. There is a problem in finding a new institution.

environmental monitoring networks of the Bureau of Radiological Health, these eight institutions are being sampled in the same manner as the basic stations.

Annual averages

Annual average radionuclide concentrations and intakes are presented in tables 3, 4, and 5 for the basic and auxiliary stations. During 1968, the annual average intake for the basic stations was 1.83 kg/day as compared to 1.86 kg/day in the auxiliary stations. The levels of radionuclide intake in both the basic and auxiliary stations were similar.

Recent coverage in Radiological Health Data and Reports:

Period	Issue
April–June 1968	January 1969
July–September 1968	April 1969
October–December 1968	July 1969

Table 4. Strontium-89, iodine-131, and barium-140 average annual concentrations in Institutional total diets of children (9–12 years of age) 1968 not reported in table 3

Location of Institution	Month 1968	Strontium-89 (pCi/kg)	Iodine-131 (pCi/kg)	Barium-140 (pCi/kg)
Idaho	Jan.			14
Nebr:	Feb.		11	
Colo:	Mar.	6		
Nebr:				12
Idaho				17
Ohio	Apr.		13	15
Del:	June			17
Idaho:	July	6		
Mass:				20
Del:	Aug.			19
Maine:				14
Mo:	Sept.			20
Ohio:				21
Pa:				11
Maine:	Oct.			19
Idaho:	Nov.			11
Mass:			11	14
S. Dak:			12	13
Idaho	Dec.		14	15
Maine			14	

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(1) ANDERSON, E. C. and D. J. NELSON, JR. Surveillance for radiological contamination in foods. Amer J Public Health 52:1391–1400 (September 1962).

(2) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclides in Institutional total diet samples, January–March 1965. Radiol Health Data 6:548–554 (October 1965).

(3) PUBLIC HEALTH SERVICE, NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Radionuclides in Institutional total diet samples, January–March 1968. Radiol Health Data Rep 9:557–560 (October 1968).

(4) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Table 5. 1968 annual average concentration and intake of stable elements and radionuclides in Institutional total diets of individuals (auxiliary stations)

Location of Institution		Total weight (kg/day)	Calcium		Potassium		^{90}Sr		^{137}Cs		^{226}Ra	
			(g/kg)	(g/day)	(g/kg)	(g/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)
Alaska:	Juneau	1.26	0.6	0.7	1.7	2.0	7	10	14	17	0.4	0.6
Calif:	San Francisco	2.23	.8	1.5	1.6	3.6	5	10	6	13	.6	1.3
Miss:	Columbia	2.11	.8	1.8	1.5	2.7	11	24	13	26	.5	1.2
Nebr:	Omaha	2.30	.9	2.0	1.6	3.5	7	15	7	15	1.0	2.1
Nev:	Carson City	1.57	.7	1.1	1.6	2.6	5	7	9	15	.6	.9
N.Mex:	Albuquerque	2.02	.6	1.4	1.6	3.1	5	9	0	0	.4	.9
Oregon:	Portland	2.28	.6	1.3	1.8	4.2	5	12	17	39	.5	1.1
Utah:	Salt Lake City	1.17	.9	1.2	1.3	2.5	5	10	8	9	.4	.8
Institutional average		1.86	0.7	1.4	1.6	3.0	6	12	9	17	0.6	1.1

* Since strontium–89, iodine–131, and barium–140 were not detected at most stations during the year 1968, no provision was made for these radionuclides in the table. The exceptions for strontium–89 are as follows:

January 1968: 9 pCi/kg was reported in Portland, Ore.
April 1968: 7 pCi/kg was reported in San Francisco, Calif. and
10 pCi/kg was reported in Portland, Ore.
November 1968: 6 pCi/kg was reported in San Francisco, Calif.

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

Water sampling program	Period reported	Issue
California	July–December 1967	November 1968
Colorado River Basin	1967	December 1968
Drinking Water Analysis Program	1961–1966	August 1968
Florida	1967	February 1969
Kansas	July–December 1967	November 1968
Minnesota	January–June 1968	February 1969
New York	July–December 1968	September 1969
North Carolina	January–December 1967	May 1969
Radiostrontium in Tap Water, *HASL*	January–June 1968	April 1969
Washington	July 1967–June 1968	June 1969

REFERENCES

(*1*) U. S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies, Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Gross Radioactivity in Surface Waters of the United States March 1969

Division of Pollution Surveillance
Federal Water Pollution Control Administration
Department of the Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Water Pollution Surveillance System currently operated by the Federal Water Pollution Control Administration. Table 1 presents the current preliminary results of the alpha and beta radioanalyses. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the November 1968 issue of *Radiological Health Data and Reports*.

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (*1–6*). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data for comment. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or

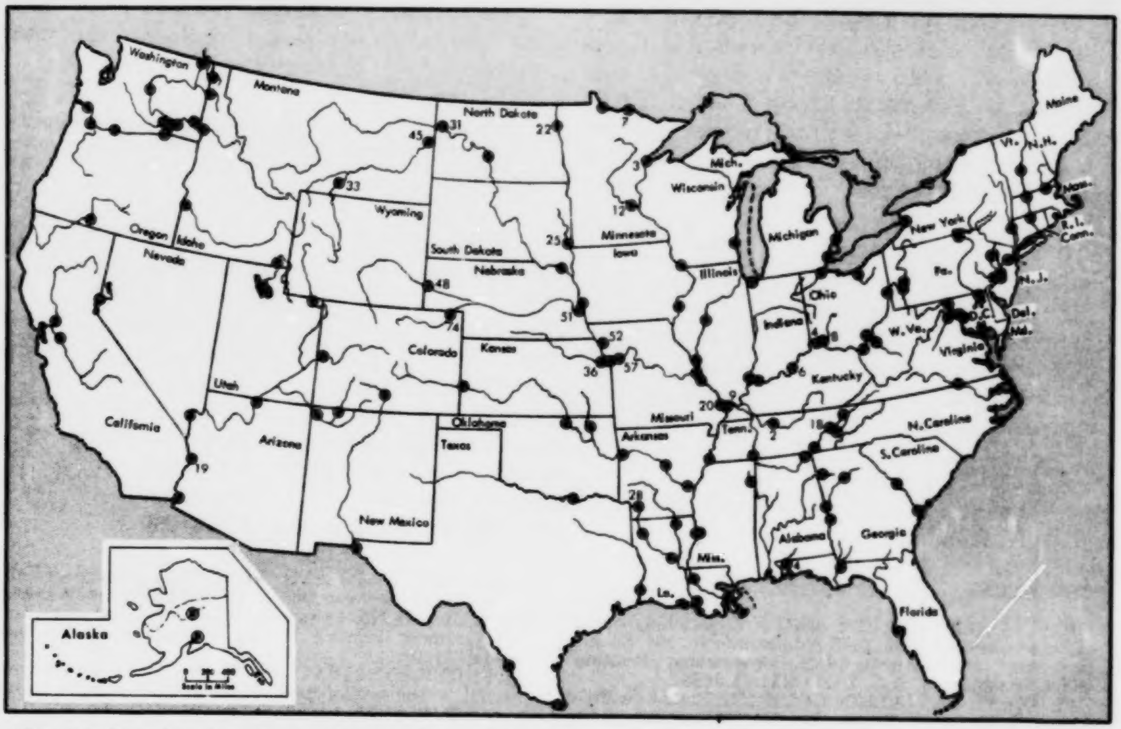

Washington
Montana
North Dakota
Minnesota
Wisconsin
Mich.
Michigan
New York
Vt.
N.H.
Maine
Mass.
R.I.
Conn.
Pa.
N.J.
Del.
Md.
D.C.
Oregon
Idaho
Nevada
Wyoming
South Dakota
Nebraska
Iowa
Illinois
Indiana
Ohio
W. Va.
Virginia
Kentucky
Utah
Colorado
Kansas
Missouri
California
Arizona
Oklahoma
Texas
New Mexico
Arkansas
Tenn.
N. Carolina
S. Carolina
Georgia
Alabama
Miss.
La.
Florida
Alaska
Scale in Miles
45
31
22
7
3
33
12
25
48
51
74
52
36
57
20
9
19
28
4
8
6
2
18

Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, March 1969

Table 1. Radioactivity in raw surface waters, March 1969

Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Big Horn River:						
Hardin, Mont	3	3	6	13	20	33
Big Sioux River:						
Sioux Falls, S. Dak	<1	12	12	4	31	35
Clinch River:						
Kingston, Tenn[a]	0	<1	<1	2	16	18
Colorado River:						
Parker Dam, Calif-Ariz	0	0	0	0	19	19
Cumberland River:						
Cheatham Lock, Tenn	0	0	0	0	2	2
Escambia River[b]						
Century, Fla	1	0	1	3	4	7
Great Lakes:						
Duluth, Minn	0	0	0	1	2	3
Kansas River:						
DeSoto, Kans	5	2	7	25	11	36
Little Miami River:						
Cincinnati, Ohio	0	1	1	1	7	8
Mississippi River:						
St. Paul, Minn	0	1	1	1	11	12
Cape Girardeau, Mo	3	2	5	12	8	20
Missouri River:						
Williston, N. Dak	2	5	7	10	21	31
St. Joseph, Mo	10	3	13	42	10	52
Missouri City, Mo	10	2	12	48	9	57
North Platte River:						
Henry, Nebr	1	32	33	14	42	56
Ohio River:						
Cincinnati, Ohio	0	<1	<1	<1	4	4
Louisville, Ky	0	0	0	2	4	6
Cairo, Ill	1	0	1	2	7	9
Platte River:						
Plattsmouth, Nebr	11	3	14	35	16	51
Rainy River:						
International Falls, Minn	0	0	0	0	7	7
Red River North:						
Grand Forks, N. Dak	0	0	0	2	20	22
Red River South:						
Index, Ark	5	1	6	19	9	28
South Platte River:						
Julesburg, Colo	2	39	41	12	62	74
Yellowstone River:						
Sidney, Mont	5	3	8	24	21	45
Maximum	11	39	41	48	62	74
Minimum	0	0	0	0	2	2

[a] Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides.

[b] Quarterly composite sample, January–March 1969.

towards these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. A discussion of gross radioactivity per gram of solids for all stations in the Water Pollution Surveillance System for 1961 through 1965 has been presented (*7*). Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During March 1969, the following stations showed alpha radioactivity values in excess of 15 pCi/liter for dissolved solids:

North Platte River; Henry, Nebr.
South Platte River; Julesburg, Colo.

None of the stations showed a gross beta radioactivity in excess of 150 pCi/liter during March 1969.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data, PHS Publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(*2*) *Ibid.*, 1959 Edition.

(*3*) *Ibid.*, 1960 Edition.

(*4*) *Ibid.*, 1961 Edition.

(*5*) *Ibid.*, 1962 Edition.

(*6*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(*7*) JULIAN, E. C. Gross radioactivity of the solids in selected surface waters of the United States, 1961–1965. Radiol Health Data Rep 9:1–15 (January 1968).

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports*.

Network	Period	Issue
HASL 80th Meridan Network	July–December 1967	September 1968
Plutonium in Airborne Particulates	January–March 1968	January 1969

1. Radiation Alert Network
June 1969

Bureau of Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Bureau of Radiological Health officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Radiological Surveillance Branch, Division of Environmental Radiation, BRH, Rockville, Md. A detailed description of the sampling and analytical procedures was presented in the April 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during June 1969. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.

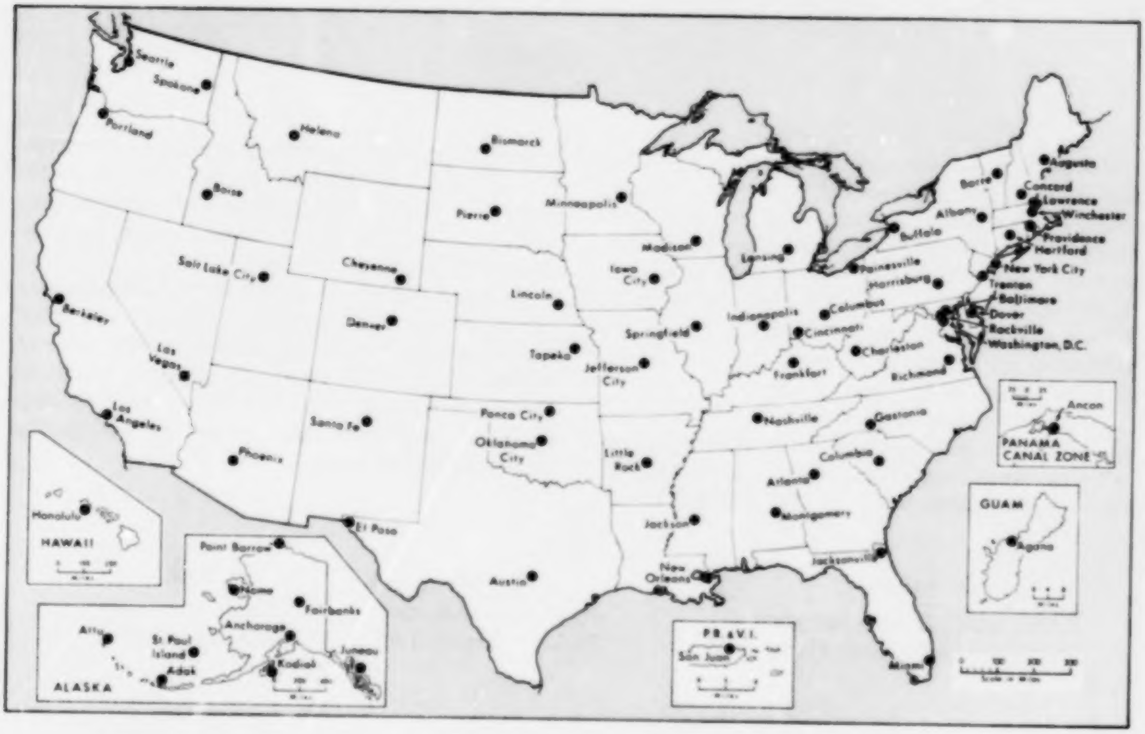

Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Augusta
Barre
Concord
Lawrence
Winchester
Albany
Buffalo
Providence
Hartford
Madison
Lansing
Painesville
New York City
Trenton
Baltimore
Dover
Rockville
Washington, D.C.
Salt Lake City
Cheyenne
Iowa City
Harrisburg
Lincoln
Berkeley
Denver
Indianapolis
Columbus
Springfield
Cincinnati
Charleston
Topeka
Jefferson City
Frankfort
Richmond
Las Vegas
Ancon
PANAMA CANAL ZONE
Los Angeles
Santa Fe
Ponca City
Nashville
Gastonia
Oklahoma City
Phoenix
Little Rock
Columbia
Atlanta
GUAM
Agana
Honolulu
HAWAII
Jackson
Montgomery
El Paso
Point Barrow
Jacksonville
New Orleans
Austin
Nome
Fairbanks
Anchorage
Attu
St Paul Island
Adak
Kodiak
Juneau
ALASKA
P R & V I
San Juan
Miami

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, June 1969

Station location	Number of samples	Air surveillance, gross beta radioactivity (pCi/m³)			Last profile in RHD&R	Precipitation				
	Air	Maximum	Minimum	Average ᵃ		Number of samples	Total depth (mm)	Field estimation of deposition: Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala: Montgomery	21	7	1	2	July 69	4	40	4	40	32
Alaska: Adak	21	2	1	1	Feb 69	(c)				
Anchorage	(b)				Aug 69	(c)				
Attu Island	19	1	0	0	Mar 69	(c)				
Fairbanks	(b)				Sept 69	(c)				
Juneau	19	1	0	0	Dec 68	5	57	5	57	0
Kodiak	(b)				Jan 69	(c)				
Nome	(b)				May 69	(c)				
Point Barrow	30	0	0	0	Apr 69	(c)				
St. Paul Island	(b)				June 69	(c)				
Ariz: Phoenix	21	7	2	3	Dec 68	(c)				
Ark: Little Rock	2	2	0	1	Aug 69	(c)				
Calif: Berkeley	21	2	0	0	Jan 69	(c)				
Los Angeles	21	1	0	0	May 69	(c)				
C.Z: Ancon	7	0	0	0	Jan 69	(c)				
Colo: Denver	18	6	0	2	Jan 69	5	43	(d)		
Conn: Hartford	17	0	0	0	Sept 69	6	65	5	64	4
Del: Dover	19	1	0	1	July 69	(c)				
D.C: Washington	31	3	0	1	Apr 69	6	29	6	29	23
Fla: Jacksonville	19	1	0	1	Aug 69	6	135	6	135	58
Miami	16	1	0	0	Sept 69	9	214	9	214	0
Ga: Atlanta	20	3	1	2	June 69	1	23	1	23	23
Guam: Agana	(b)				July 69	(c)				
Hawaii: Honolulu	28	2	0	1	Mar 69	(c)				
Idaho: Boise	22	3	0	1	Mar 69	6	60	6	60	5
Ill: Springfield	20	5	1	2	Apr 69	(c)				
Ind: Indianapolis	22	5	0	2	June 69	8	85	8	85	33
Iowa: Iowa City	16	3	0	1	Jan 69	8	202	8	202	0
Kans: Topeka	21	3	0	1	Aug 69	10	216	10	216	30
Ky: Frankfort	14	3	1	1	Apr 69	(c)				
La: New Orleans	15	1	0	1	Apr 69	6	33	(d)		
Maine: Augusta	5	1	0	0	May 69	1	1	1	1	0
Md: Baltimore	21	3	0	1	Sept 69	2	20	2	20	19
Rockville	11	1	0	1	Mar 69	(c)				
Mass: Lawrence	11	2	0	1	July 69	1	7	1	7	3
Winchester	20	3	0	1	Feb 69	5	54	5	54	0
Mich: Lansing	21	2	0	1	Mar 69	11	100	11	100	92
Minn: Minneapolis	21	2	0	1	July 69	8	91	8	91	12
Miss: Jackson	18	4	0	1	May 69	(c)				
Mo: Jefferson City	21	2	0	1	June 69	10	212	10	212	0
Mont: Helena	15	6	1	3	Feb 69	5	4	5	4	6
Nebr: Lincoln	14	7	1	4	June 69	5	61	5	61	15
Nev: Las Vegas	18	4	0	2	Sept 69	(c)				
N.H: Concord	15	2	0	1	Apr 69	(c)				
N.J: Trenton	21	2	0	1	May 69	5	75	5	75	31
N. Mex: Santa Fe	10	3	1	1	Feb 69	1	21	1	21	25
N.Y: Albany	(b)				June 69	(c)				
Buffalo	21	2	0	1	Jan 69	(c)				
New York City	20	1	0	0	Feb 69	(c)				
N.C: Gastonia	17	9	1	4	Jan 69	4	16	(d)		
N. Dak: Bismarck	20	3	0	1	Apr 69	8	73	8	73	0
Ohio: Cincinnati	(b)				July 69	(c)				
Columbus	19	3	0	1	May 69	6	137	0	0	(e)
Painesville	21	5	1	1	Sept 69	9	123	9	123	41
Okla: Oklahoma City	19	3	0	1	Mar 69	2	64	2	64	4
Ponca City	21	2	0	1	Sept 69	9	161	9	161	0
Ore: Portland	21	2	0	1	June 69	9	63	9	63	3
Pa: Harrisburg	(b)				June 69	(c)				
P.R: San Juan	(b)				May 69	(c)				
R.I: Providence	13	2	0	1	Mar 69	5	31	5	31	11
S.C: Columbia	16	3	0	1	Feb 69	5	56	5	56	3
S. Dak: Pierre	11	8	1	3	Dec 68	(c)				
Tenn: Nashville	19	2	0	1	Mar 69	5	72	5	72	5
Tex: Austin	17	7	1	3	July 69	1	21	(d)		
El Paso	(b)				Apr 69	(c)				
Utah: Salt Lake City	26	4	0	1	May 69	7	111	7	111	33
Vt: Barre	13	3	1	1	Aug 69	12	225	12	225	63
Va: Richmond	20	1	0	0	Aug 69	6	138	6	138	71
Wash: Seattle	6	1	0	0	Aug 69	5	25	(d)		
Spokane	11	2	0	1	July 69	(c)				
W. Va: Charleston	19	4	0	1	Feb 69	9	37	9	37	5
Wisc: Madison	19	1	0	1	Aug 69	12	220	12	220	39
Wyo: Cheyenne	21	6	1	2	Sept 69	7	75	7	75	49
Network summary	1,112	9	0	1		6	82	6	90	21

ᵃ The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
ᵇ No report received. (Air samples received without field estimate data are not considered by the data program.)
ᶜ No precipitation sample collected.
ᵈ This station is part of the plutonium in precipitation network. No gross beta measurements are done.
ᵉ Samples were collected but no field estimates were received.

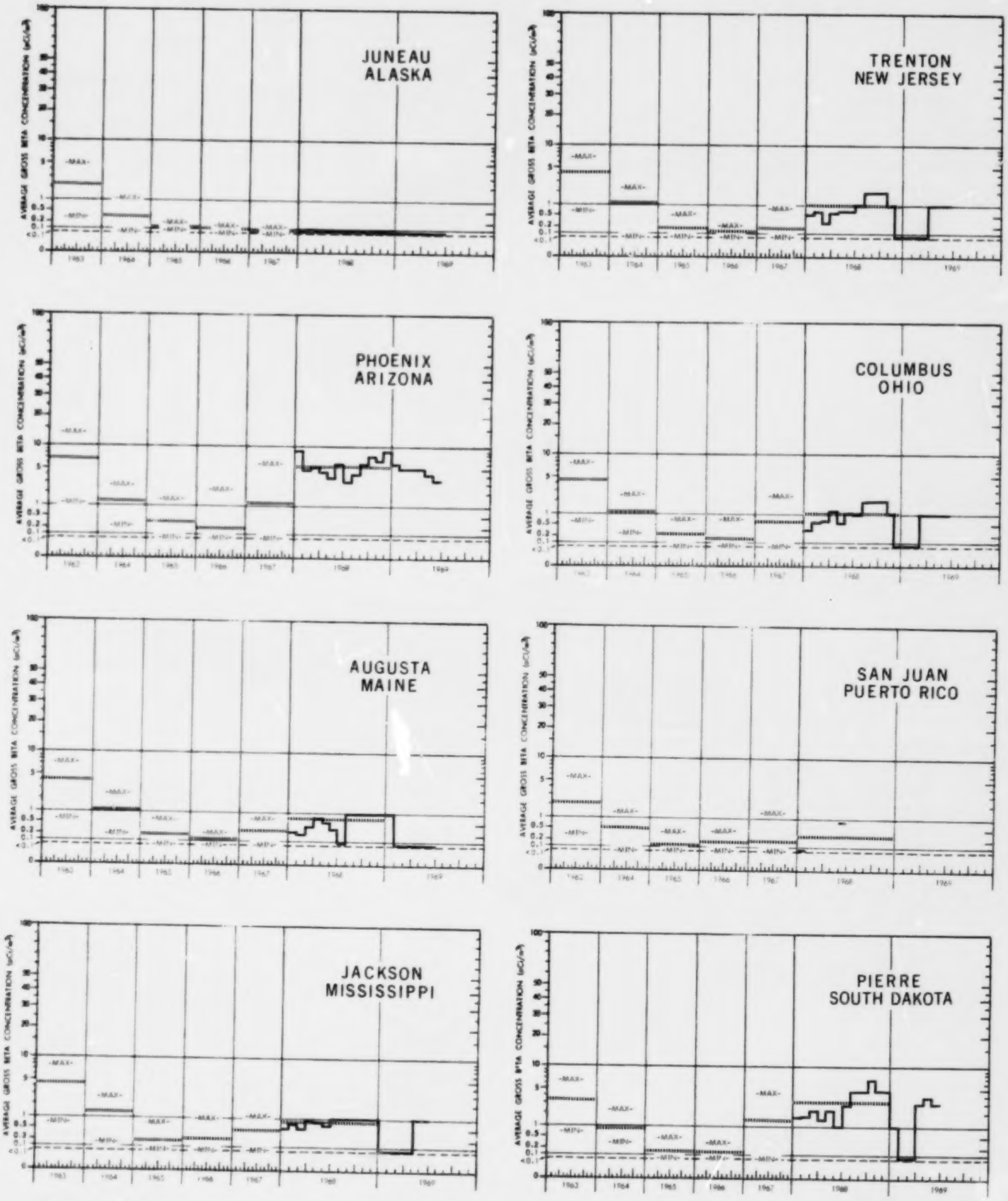


Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network, 1963–June 1969

2. Canadian Air and Precipitation Monitoring Program,[1] June 1969

Radiation Protection Division
Department of National Health and Welfare

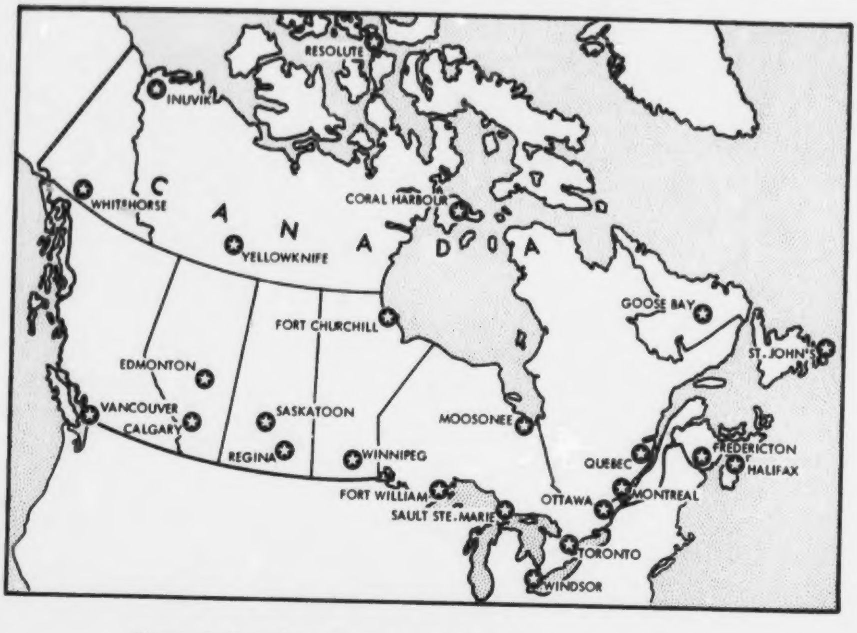
The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meterological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the September 1969 issue of *Radiological Health Data and Reports*.

Surface air and precipitation data for June 1969 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, June 1969

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	14	0.6	0.1	0.4	55	7.0
Coral Harbour	29	.1	.0	.1	14	.2
Edmonton	30	.7	.1	.3	54	1.9
Ft. Churchill	25	.4	.0	.1	169	2.9
Ft. William	30	.3	.1	.2	172	9.8
Fredericton	28	.5	.0	.2	105	6.9
Goose Bay	27	.4	.0	.2	74	6.6
Halifax	30	.5	.0	.2	92	4.0
Inuvik	30	.3	.0	.1	426	2.1
Montreal	30	.6	.0	.3	78	9.2
Moosonee	28	.6	.0	.2	139	17.2
Ottawa	30	.6	.0	.3	146	13.4
Quebec	30	.5	.0	.2	94	10.9
Regina	30	.7	.1	.3	48	2.3
Resolute	29	.2	.0	.1	121	.3
St. John's, Nfld	28	.4	.0	.1	25	1.5
Saskatoon	30	.6	.1	.3	194	6.9
Saulte Ste Marie	30	.4	.0	.2	71	15.8
Toronto	30	.6	.0	.3	164	7.8
Vancouver	30	.7	.0	.2	96	1.6
Whitehorse	30	.9	.0	.4	191	5.2
Windsor	30	.6	.0	.2	103	13.4
Winnipeg	30	.4	.1	.3	167	17.5
Yellowknife	30	.4	.0	.2	290	3.1
Network summary	688	0.9	0.0	0.2	129	7.0


RESOLUTE
INUVIK
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WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
FORT CHURCHILL
ST. JOHN'S
EDMONTON
SASKATOON
VANCOUVER
CALGARY
MOOSONEE
REGINA
WINNIPEG
QUEBEC
FREDERICTON
HALIFAX
FORT WILLIAM
OTTAWA
MONTREAL
SAULT STE. MARIE
TORONTO
WINDSOR

Figure 3. Canadian air and precipitation sampling stations

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[1] Prepared from information and data in the July 1969 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

3. Mexican Air Monitoring Program September–October 1968

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Lius Potosí; and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Déserticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air

Table 3. Mexican gross beta radioactivity of airborne particulates, September 1968

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	7	0.1	0.1	0.1
Chihuahua	15	.8	.1	.2
Ciudad Juarez	NS			
Ensenada	11	.3	.1	.2
Guadalajara	NS			
Guaymas	NS			
La Paz	13	.3	.1	.1
Matamoros	NS			
Mazatlan	1	.1	.1	.1
Mérida	15	.2	.1	.1
México, D.F.	NS			
Nuevo Laredo	12	.4	.2	.2
San Luis Potosi	NS			
Tampico	11	.1	.1	.1
Torreón	1	.1	.1	.1
Veracruz	14	.3	.1	.1

NS, no sample, station temporarily shutdown.

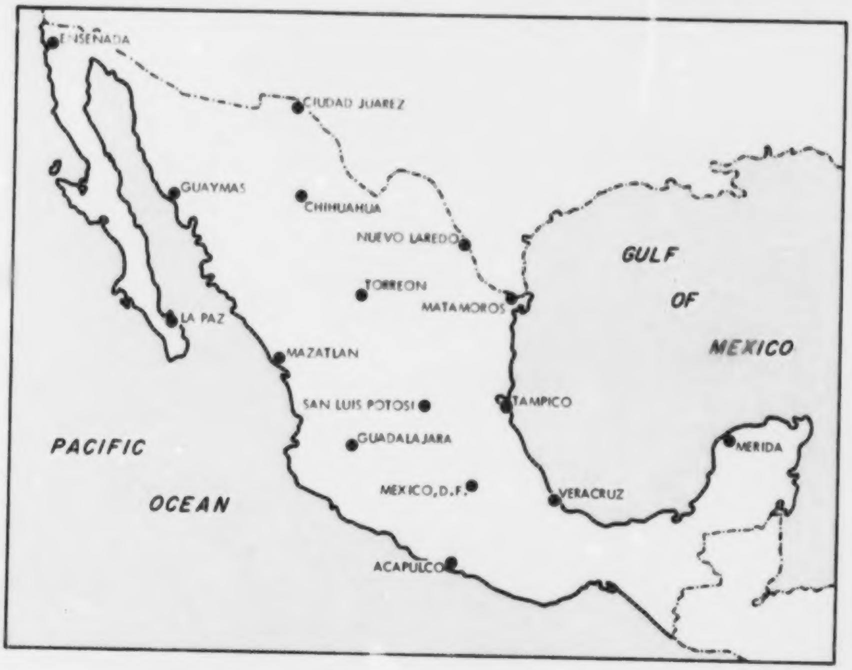

Figure 4. Mexican air sampling locations

through a high-efficiency 6 by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week, at the rate of 1,000 cubic meters per day using high volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Seccion de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron daughters. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of five samples per month were needed to get a reliable average radioactivity at each station (*6*).

The maximum, minimum, and average beta radioactivity in surface air during September and October 1968 are presented in tables 3 and 4.

Table 4. Mexican gross beta radioactivity of airborne particulates, October 1968

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	11	0.1	0.1	0.1
Chihuahua	6	.2	.1	.2
Ciudad Juarez	NS			
Ensenada	5	.2	.1	.2
Guadalajara	NS			
Guaymas	NS			
La Paz	7	.4	.1	.2
Matamoros	NS			
Mazatlan	NS			.1
Mérida	7	.2	.1	.1
México, D.F.	1	.9	.9	.9
Nuevo Laredo	1	.2	.2	.2
San Luis Potosi	NS			
Tampico	9	.3	<.1	.1
Torreón	2	.9	.8	.8
Veracruz	13	.6	.1	.2

NS, no sample, station temporarily shutdown.

4. Pan American Air Sampling Program June 1969

Pan American Health Organization and
U.S. Public Health Services

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 5. It should be noted that a new sampling station has been established in Cuenca, Ecuador.

Table 5. Summary of gross beta radioactivity in Pan American surface air, June 1969

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	9	0.08	0.00	0.04
Bolivia:	La Paz	12	.33	.01	.12
Chile:	Santiago	28	.63	.03	.20
Colombia:	Bogota	17	.02	.00	.01
Ecuador:	Cuenca	11	.01	.00	.01
	Guayaquil	21	.33	.03	.12
	Quito	19	.25	.00	.08
Guyana:	Georgetown	10	.72	.06	.38
Jamaica:	Kingston	17	.56	.03	.19
Peru:	Lima	6	.13	.05	.08
Venezuela:	Caracas	17	.23	.01	.10
West Indies:	Trinidad	19	.28	.01	.13
Pan American summary		186	0.72	0.00	0.13

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

Analytical techniques were described in the January 1968 *Radiological Health Data and Reports*. The June 1969 air monitoring results from the participating countries are given in table 5.

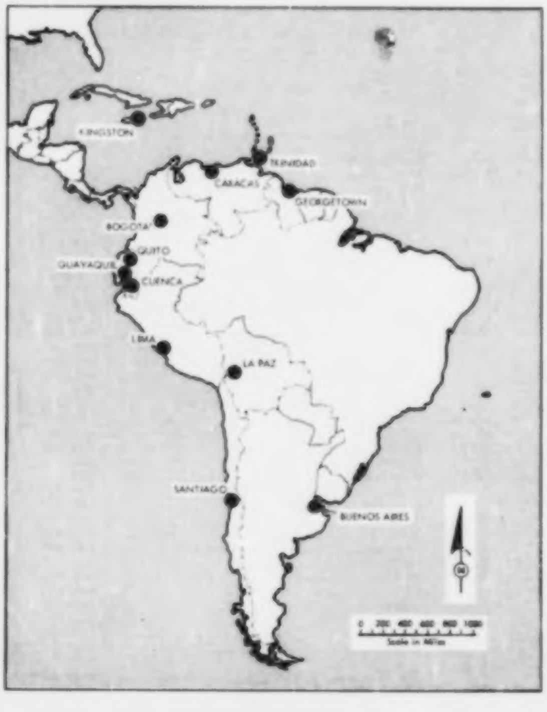

Figure 5. Pan American Air Sampling Program stations

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5. Fallout in the United States and Other Areas January–June 1968[2]

Health and Safety Laboratory
U.S. Atomic Energy Commission

Monthly fallout deposition rates for strontium-90 are determined by the Health and Safety Laboratory (HASL) for 36 sites in the United States and 103 locations in other countries. HASL data from all of the active United States stations and other selected points in the Western Hemisphere (figure 6) covering the period from January–June 1968 are summarized in tables 6 and 7. All the stations of the 80th Meridian Network are represented.

Methods of collection

Two methods of fallout collection are employed by HASL. In the first, precipitation and dry fallout are collected for a period of 1 month in a stainless-steel pot with an exposure area of 0.076 m². At the end of the collection period, the contents are transferred by careful scrubbing with a rubber spatula, to a polyethylene sample bottle which is then shipped to the laboratory for analysis.

The second method involves the use of a polyethylene funnel with an exposed area of 0.072 m², attached to an ion exchange column. After a 1-month collection, the inside of the funnel is wiped with a tissue, and the tissue is inserted in the end of the column, which is then sealed and sent to HASL for analysis. It has been shown that at the 95-percent confidence level there was no significant difference in the strontium-90 measurements obtained from samples collected by the two methods (*8*).

The analysis of monthly precipitation samples for other radionuclides that were being performed at laboratories in Westwood, N.J., New York City, N.Y., and Seattle, Wash., have been discontinued as of July 1967.

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[2] The data in this article were taken from "Fallout Program Quarterly Summary Report," HASL-204: A-5 to A-279 (January 1969). Plutonium analyses of monthly deposition are continuing at New York City and Melbourne, Australia.

Table 6. Strontium-90 fallout in the United States, HASL, January–June 1968

Sampling location		Type of collection	Deposition (nCi/m²)					
			Jan	Feb	Mar	Apr	May	June
Ala:	Birmingham	pot	0.06	0.03	0.16	0.23	0.11	T
Alaska:	Anchorage	column	T	.07	.02	.02	.10	0.06
	Barrow	column	T	T	NS	NS	NS	.02
	Cold Bay	column	.14	.05	.04	.04	.09	.04
	Fairbanks	column	.03	T	T	T	.03	.09
	Juneau	column	.05	.11	.10	.08	NS	.02
	Nome	column	NS	T	T	.01	.02	.03
Calif:	W. Los Angeles	pot	.04	.04	.06	.04	.01	.01
	San Francisco	column	.09	.04	.08	T	.02	.01
Colo:	Denver	column	T	T	.02	.07	.13	.15
Fla:	Coral Gables	pot	.09	.06	.06	NS	NS	NS
	Miami	column	.04	.07	.05	.04	.29	.11
Hawaii:	Hilo	column	.08	.04	.37	.73	.13	.15
	Honolulu	pot	.08	.87	.38	.43	.20	.22
	Lihue	column	.05	.02	.15	.11	.02	.05
	Mauna Loa	column	.01	T	.05	.11	.02	.05
Ill:	Argonne	pot	.04	.05	.04	.18	.13	.15
La:	New Orleans	column	T	T	.01	.05	.04	.11
Minn:	International Falls	column	.02	T	.13	.08	.08	.19
Mo:	Columbia	column	.12	.02	.06	.10	.06	.16
Mont:	Helena	column	.01	T	.02	.06	.12	.25
N.J:	Westwood	pot	—	—	—	—	—	—
N.Y:	New York	pot	.07	.03	.14	.12	.32	.24
N. Dak:	Williston	column	T	T	.01	.03	.05	.29
Ohio:	Wooster	pot	.03	.01	.02	.07	.40	.16
Okla:	Tulsa	pot	.09	.03	.23	.29	.23	NS
Ore:	Medford	column	.08	.06	.06	.02	.09	.03
S.C:	Columbia	column	.07	.02	.08	.17	.09	.18
S.Dak:	Vermillion	pot	.02	.01	.07	.04	.13	.14
Tex:	Dallas	column	.02	.07	.18	.13	.11	.09
	El Paso	column	.03	.03	.05	.02	T	.02
	Houston	column	.10	.03	.09	.06	.26	.14
Utah:	Salt Lake City	pot	.01	.13	.30	.26	.34	.22
Va:	Sterling	column	.04	.02	.16	.12	.26	.24
Wash:	Seattle	pot	.13	.11	.17	.10	.30	NS
		pot	—	—	—	—	—	—
	Forks	column	.30	.21	.32	.30	.13	.13
Wisc:	Green Bay	column	.04	T	.08	.28	.32	.31

T, trace or zero.
NS, no sample.

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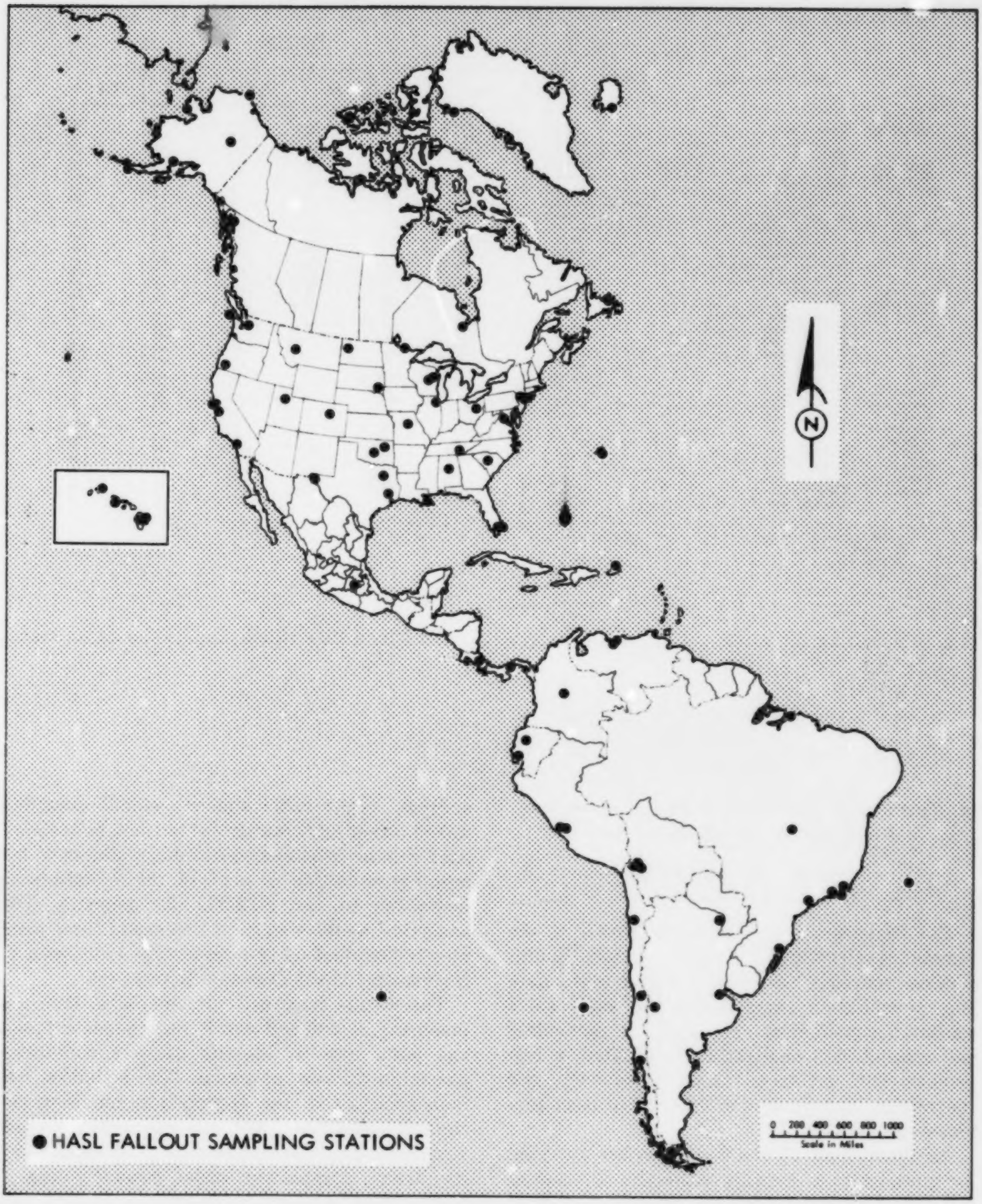
● HASL FALLOUT SAMPLING STATIONS
0 200 400 600 800 1000
Scale in Miles
N

Figure 6. HASL fallout sampling stations in the Western Hemisphere

Table 7. Strontium-90 fallout in North and South America, HASL, January–June 1968

Sampling location		Type of colection	Deposition (nCi/m²)					
			Jan	Feb	Mar	Apr	May	June
Argentina:	Buenos Aires	column	0.05	0.05	0.02	0.01	0.01	NS
	Formosa	column	.02	T	T	.01	.01	NS
	Malargue	column	.02	.02	.02	.01	.01	NS
Bahamas:	Bimini	column	.01	.05	.25	.02	NS	.09
Bermuda:	Kindley AFB	column	.06	.30	.04	.14	.09	.02
Bolivia:	Chacaltaya	column	.01	T	.01	T	.01	.01
	La Paz (city)	column	.02	T	T	T	.01	.02
	La Paz (Ovejuyo)	column	.01	.01	T	T	.01	.02
Brazil:	Itaici Sao Paulo	pot	.02	NS	NS	NS	NS	NS
	Nova Friburgo	pot	.02	.02	.01	NS	NS	NS
	Rio de Janeiro	column	.04	.05	.05	.06	NS	NS
	San Jose Dos Compos	pot	.01	NS	NS	NS	NS	NS
	Trindade Island	column	.02	.02	.05	NS	NS	NS
Canada:	Moosonee	column	T	T	.10	.16	.05	.23
Canal Zone:	Balboa	column	T	.02	.02	.03	.03	.02
Chile:	I. Alejandro Selkirk[a]	column	.02	.05	.04	.02	.01	NS
	Easter Island	column	.05	.01	.03	.02	.03	T
	Puerto Montt	column	.04	.03	.02	.03	.03	NS
	Punta Arenas	column	.01	.04	T	NS	.01	NS
	Santiago	pot	T	T	.05	T	.01	NS
		column	T	.02	.04	T	.01	.01
Colombia:	Bogota	pot	T	T	NS	T	.01	T
Costa Rica:	Turrialba	column	.03	.08	.18	.07	.03	.01
Ecuador:	Quito	column	NS	T	T	T	NS	NS
Greenland:	Thule	column	T	.01	.01	.01	.01	.04
Iceland:	Keflavik	column	NS	NS	NS	.10	.09	.08
Mexico:	Mexico City	column	.01	.01	T	.06	.06	.06
Peru:	Lima	column	T	T	T	T	.01	.01
Puerto Rico:	San Juan	column	T	.04	.12	.05	.11	.09
Venezuela:	Caracas (site 1)	column	T	T	.01	.02	.03	.03
	Caracas (site 2)	column	.01	T	T	.02	.03	.03

[a] Isla Robinson Crusoe.
T, trace or zero.
NS, no sample.

6. Plutonium in Airborne Particulates and Precipitation, April–June 1968

Bureau of Radiological Health
U.S. Public Health Service

The Radiation Alert Network (RAN) of the Bureau of Radiological Health, Public Health Service, routinely analyzes airborne particulate and precipitation samples from selected RAN stations for plutonium. The airborne particulate and precipitation analyses were initiated in November 1965 and August 1966 respectively, and the results through March 1968 have been previously reported *(9–16)*.

Air filters from 11 RAN stations are analyzed for plutonium. A monthly composite is made of one-half of each individual air filter from each of the 11 stations and sent to the PHS Northeastern Radiological Health Laboratory (NERHL) for analysis. Eight RAN stations submit complete collections of precipitation for plutonium analysis. An 8-liter or (whatever is available) aliquot of the monthly collection of each of the 8 stations is forwarded to the NERHL for analysis. The analytical methodology for processing these samples is described in the December 1968 issue of *Radiological Health Data and Reports* (*15*).

The results for April through June 1968 are presented in tables 8 and 9. ND (nondetectable) has been used to indicate samples containing plutonium-238 or plutonium-239 activities less than or equal to the appropriate minimum detectable activities (.020 pCi and .015 pCi per sample for plutonium-238 and plutonium-239, respectively). Sample size varies, generally ranging from 20,000 to 30,000 cubic meters of air for the air filter samples, and from 2 to 8 liters for the precipitation samples.

Table 8. Plutonium 238 and plutonium-239 in precipitation, April–June 1968

	Gastonia	Rockville	Pierre	New Orleans	Austin	Denver	Honolulu	Seattle
Precipitation depth (mm)								
April	43	NS	NS	21	71	44	75	38
May	31	NS	NS	31	173	22	NS	75
June	18	NS	NS	18	80	17	8	15
Concentration (pCi/liter)								
Plutonium-239								
April	0.019			.017	.008	.010	ND	.005
May	ND			.009	.009	.023		.010
June	.005			.030	.005	.051	.017	.016
Plutonium-238								
April	.015			.006	ND	.003	NA	ND
May	.004			ND	NA	.007		NA
June	ND			.014	ND	.009	ND	.005
Deposition (pCi/m²)								
Plutonium-239								
April	.82			.36	.57	.44		.10
May				.28	1.56	.51		.75
June	.09			.54	.40	.87	.14	.24
Plutonium-238								
April	.65			.13		.13		
May	.12					.15		
June				.25		.15		.08

[a] The basic finding is the concentration (pCi/liter). This figure is multiplied by the depth of precipitation for the month (mm) to obtain the total deposition (pCi/m²). One liter of water is collected when 1 mm of precipitation falls on 1-square meter.

NS, no sample.
ND, nondetectable.
NA, no analysis.

Table 9. Plutonium in airborne particulates, April–June 1968

	Buffalo	Gastonia	Rockville	Pierre	New Orleans	Austin	Denver	Anchorage	Phoenix	Honolulu	Seattle
Plutonium-238: (fCi/m³)											
April	0.008	0.014	NS	0.005	0.013	0.015	0.017	0.006	0.028	0.005	0.004
May	.005	.011	NS	.012	.013	.008	.015	ND	.021	.006	.007
June	.007	.011	NS	.007	.010	.003	.011	.005	.015	.006	.007
Plutonium-239: (fCi/m³)											
April	.030	.068	NS	.032	.009	.052	.095	.017	.120	.029	.019
May	.024	.050	NS	.055	.065	.038	.088	.007	.110	.028	.031
June	.044	.052	NS	.042	.049	.028	.092	.020	.090	.029	.032
$^{239}Pu/^{238}Pu$											
April	3.75	4.86		6.40	5.31	3.47	5.58	2.83	4.29	3.80	4.75
May	4.80	4.55		4.58	5.00	4.75	5.87		5.24	4.67	4.43
June	6.29	4.73		6.00	4.90	9.33	5.64	4.00	6.00	4.83	4.57

NS, no sample.
ND, nondetectable (see text).

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, bovine thyroid sampling, Alaskan surveillance and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for the Lawrence Radiation Laboratory and Shippingport Atomic Power Station.

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[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Lawrence Radiation Laboratory[2]

January–December 1968

University of California
Berkeley, Calif.

Berkeley site

The Berkeley site of the Lawrence Radiation Laboratory (LRL) is situated on the western slope of the range of hills running along the eastern side of San Francisco Bay. The laboratory area is largely separate from the main campus of the University, although there is some overlap (figure 1).

To the north and south of the laboratory area are residential areas of the cities of Berkeley and Oakland. The Berkeley campus of the University of California is on the west; to the east, are the Lawrence Hall of Science and the Space Sciences Laboratory, beyond them lies uninhabited watershed land and the Tilden Regional Park.

The most prevalent wind direction is westerly. During the summer months the afternoon sea breeze establishes a very pronounced prevailing westerly wind direction. At other times, the direction is less predictable. Annual rainfall is 23 inches, almost all of which falls between November 1 and May 1. The prevailing wind direction during precipitation is southerly.

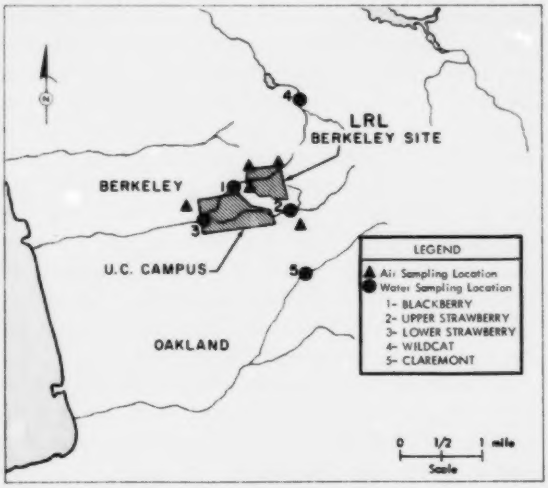

Figure 1. Environmental sampling locations at the Berkeley site, Lawrence Radiation Laboratory

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[2] Summarized from "Results of Environmental Radioactivity Sampling Program, January–December 1968," Lawrence Radiation Laboratory, Livermore and Berkeley, Calif.

The laboratory carries on a wide ranging program of general research in the fields of both physical and biological sciences. Facilities include a number of large accelerators, and various physics, chemistry, biology, and medical research laboratories.

The basic policy at LRL has long been to prevent, as far as possible, any release of radioactive material to the environment, no matter how small. No deliberate releases are sanctioned, except where no practical method for containment has yet been developed and quantities are small compared with standards established by the ICRP and AEC.

The most sensitive measurements of releases are those taken closest to the source itself, before dilution makes detection of small quantities more difficult. The stack sampling program, therefore, provides the most useful information for controlling releases to the atmosphere. Over 100 separate exhausts from hoods and glove-box manifolds are sampled. The total quantities released from these stacks during January–June 1968 were 1.0 mCi of alpha-particle emitters and 200 mCi of beta-particle emitters; July–December 1968 were 0.8 mCi of alpha-particle emitters and 290 mCi of beta-particle emitters. The average concentrations in the total exhaust, before any dilution by the atmosphere, was 9 percent of the maximum permissible concentration for offsite breathing zone air, as given by the ICRP.

In addition to the careful sampling of stacks, an environmental air sampling program is also carried on to make sure no undetected releases occur. These samples provide a direct measurement of possible exposure to the nearby population. The sampling stations designated "local area" are scattered around the site and provide samples of the atmosphere on the site itself. The "perimeter" samples are taken at the boundary line of University property, in the direction of populated areas. From the results of these samples, it is apparent that there has been no significant exposure from radioactive materials released by LRL. The levels of radioactivity observed in each type of sample are presented in table 1.

At each of these environmental stations rain or dry "fallout" is also collected. Open 15-inch diameter polyethylene bags form the collecting vessel. If no rain has fallen, the bags are rinsed out with dilute nitric acid. Results from these collections show a lot of variation, without any consistent pattern. Since on the average, the more remote perimeter stations show about the same radioactivity as the nearer ones, it must be assumed that the radioactivity does not result from laboratory operations. The radioactivity levels in samples collected at each location are summarized in table 2.

Table 1. Atmospheric monitoring, LRL Berkeley Site January–December 1968

Sampling locations (number of locations)	Number of samples	Average concentration (pCi/m^3)			
		Alpha radioactivity		Beta radioactivity	
		January–June	July–December	January–June	July–December
Local area (10)...	503	0.001	0.001	0.27	0.09
Perimeter (4).....	199	.001	.001	.32	.10

Table 2. Total deposition, LRL Berkeley Site January–June 1968

Sampling locations (number of locations)	Number of samples	Average deposition (nCi/m^2)			
		Alpha radioactivity		Beta radioactivity	
		January–June	July–December	January–June	July–December
Local area (10)...	117	0.08	0.06	13.43	3.74
Perimeter (4).....	48	.05	.10	14.05	4.63

All liquid waste known to be radioactive is collected, solidified, and shipped away. Other liquid wastes are discharged directly to the municipal sewer system. Small quantities of radioisotopes now and then are accidentally released to the sewer system. There are two outfalls, each of which is monitored by a continuous proportional sampling system to insure that no significant quantities have been discharged. The total concentration (alpha-plus-beta radioactivity) in sewage is only 28 percent for the period, January–June 1968 and 17 percent (July–December 1968), of the standard for drinking water and therefore does not constitute a serious exposure threat. A sizeable fraction of the measured beta concentration is the naturally occurring isotope potassium-40 from human wastes and chemicals.

The storm drainage from the laboratory flows into the surface stream system. These surface streams are exposed as they run through the University property and are sampled at three places. Results are listed as "onsite streams" in table 3. Two nearby offsite streams are also sampled to provide a comparison. All concentrations are safely below the standard for drinking water. The results from the water sampling program are presented in table 3.

Neutron and gamma-ray fields are measured at each of the four perimeter stations as well as at several locations within the site. Background measurements are obtained from a leased building used as a low-level counting room in downtown Berkeley. This building is remote from the main LRL site and measurements are not influenced by accelerator operations.

Table 3. Water monitoring, LRL Berkeley site January–December 1967

Type and source of sample	Number of samples	Average concentration (pCi/liter)			
		Alpha radioactivity		Beta radioactivity	
		January–June	July–December	January–June	July–December
Sewage:					
Hearst sewer Strawberry sewer	101	0.06	0.08	27.1	15.9
Tap water	51	.01	.07	1.91	1.58
Surface water:					
Onsite streams	153	.51	.24	6.13	6.26
Offsite streams	102	.38	.30	2.79	2.79

Livermore site

The Livermore site of LRL (figure 2) is located in the Livermore Valley midway between the Pacific coast and the San Joaquin Valley in northern California—approximately 50 miles southeast of San Francisco. Shielded from the ocean by the western hills, the Livermore Valley has a warm, dry climate. Annual rainfall for 1968 was 13.4 inches and the relative humidity is about 30 percent during the summer months and about 40–50 percent the remainder of the year. Prevailing winds are from the west, but inversions are frequent during the night.

Agriculture is the principal activity in the Livermore Valley. Roses, grain, hay, and grapes are the major products. Several cattle and sheep ranches surround the Livermore site.

The Livermore site comprises an area of 1-square mile, approximately 3 miles east of the city of Livermore. Livermore and Pleasanton, with a combined population of 45,000 are populated areas of primary interest to the Livermore site.

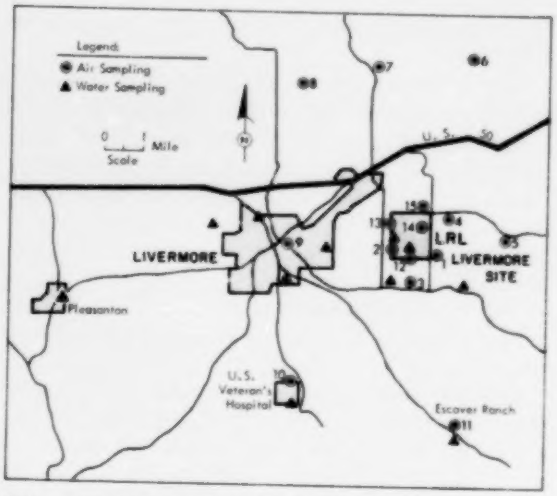

Figure 2. Environmental sampling locations at the Livermore site, Lawrence Radiation Laboratory

An environmental sampling program is maintained to provide information regarding the effectiveness of control measures and to determine whether any radiological changes in the environment are the result of laboratory operations. The sampling program includes air particulates, soil, domestic water, sewer effluent, sewage plant products, milk, and vegetation. The milk samples are obtained from one dairy in the Livermore Valley and from another dairy near Site 300. Air and soil samples are collected to ascertain that control efforts are restricting the release of radioactivity from the laboratory to levels which do not exceed the permissible levels for the neighborhood around an atomic energy facility. The water samples are collected to monitor radioactivity in an underground water supply which provides most of the domestic water for the cities of Livermore and Pleasanton, and is the sole supply for ranches in the Livermore and Amador Valleys.

Air samples are collected continuously at 16 sites within 5 miles of the laboratory. Samples are collected at a rate of 4 cfm on 100-square centimeter HV-70 filter papers, which are changed after every 7 days of operation. A minimum decay period of 96 hours is observed before the samples are counted to eliminate the effect of natural radon and thoron daughters. All environmental air samples are counted in an automated system which utilizes gas-flow proportional detectors for both alpha and beta radioactivity measurements. Alpha radioactivity in 462 air samples collected from 16 sampling locations averaged less than 0.040 pCi/m³. The average beta radioactivity was 0.096 pCi/m³. The applicable AEC radiation protection standards are 0.040 pCi/m³ for alpha-particle emitters and 1 pCi/m³ for beta-particle emitters.

The measurement of low level "background" radiation during this period was accomplished with thermoluminescent dosimeters located at nine points on the site perimeter and at three offsite locations. The limit of detection for these dosimeters is 10 mR. One dosimeter at a point opposite cobalt-60 irradiation facility recorded 53 mR for the past 6 month period. One dosimeter opposite an experimental physics facility recorded 420 mR during the year. All others were below the limit of sensitivity or less than 0.005 mR/hr.

Domestic water samples were collected monthly from nine nearby sources. No sample showed an alpha specific radioactivity above the limit of sensitivity (5.0 pCi/liter). The beta radioactivity fluctuated from the limit of sensitivity (1.8 pCi/liter) to 26 pCi/liter. The average beta radioactivity concentration was 4.1 pCi/liter. The average alpha and beta radioactivity concentrations were below the respective standards of comparison of 10 and 100 pCi/liter stated in AEC standards.

The average tritium content was at or below the limit of sensitivity (5 pCi/liter), which is well below the standard of comparison of 3 μpCi/liter.

Samples were collected daily at the laboratory sewer discharge. The average concentration of radionuclides in the sewer effluent was 10 pCi/liter of alpha radioactivity and 128 pCi/liter of beta radioactivity. The tritium content of the effluent was 3 nCi/liter.

Samples of top layer soil are collected quarterly at the 19 sampling stations surrounding the Livermore site. The alpha radioactivity fluctuated from the limit of sensitivity (1.5 pCi/g) to 22 pCi/g. The beta radioactivity fluctuated from the limit of sensitivity (3.5 pCi/g) to 20 pCi/g, averaging 7.4 pCi/g. The concentrations detected are within the normal range for soil in the Livermore Valley.

Average radioactivity levels in monthly milk samples amounted to 3.2 pCi/liter of cesium-137 and ≤5 pCi/liter of cerium-141-144, for the two dairies. The average tritium concentration in milk was at or below the limit of sensitivity, (5 nCi/liter).

Site 300

The high explosive test area at Site 300 (figure 3) covers 10 square miles in the hills in a very sparsely populated ranching area about 15 miles southeast of Livermore and 8 miles southwest of Tracy. The chief area of concern for Site 300 is Tracy. The population there is about 15,000. Air and water samples are taken to determine whether operations at Site 300 are changing the normal radioactivity levels in the vicinity. The eight air samplers at Site 300 are operated at about 50 cfm on a continuous basis with the filter papers being changed on regular schedule. Most of these air samplers are located within the boundaries of the test site due to unavailability of power facilities offsite. Water samples are taken from onsite wells because they are the only readily accessible sources of underground water. No sample showed an alpha radionuclide concentration above the limit of sensitivity—5.0 pCi/liter. The beta concentration ranged from the limit of sensitivity (1.8 pCi/liter) to 51 pCi/liter, averaging 9.2 pCi/liter.

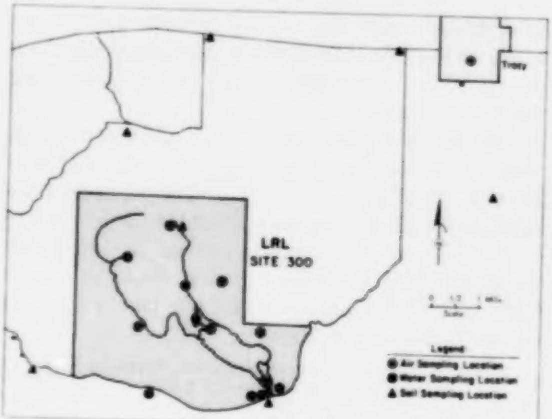

Figure 3. Sampling locations at Site 300, LRL

Soil samples are collected quarterly at nine offsite locations. The average alpha radioactivity was 2.0 pCi/g during the first 6 months and 1.5 pCi/g for the second half of 1968. The average beta radioactivity was 10 pCi/g.

None of the average concentrations of air, water, and soil samples exceeded the standards of comparison applicable to activities at the test site, nor did any of the results increase significantly compared to 1967 data. Therefore, it appears that radiological control measures at Site 300 were adequate and that no significant radioactivity was released to the environment near the site during this period.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January–June 1967	April 1968
July–December 1967	September 1968

2. Shippingport Atomic Power Station[3]
January-December 1968

Duquesne Light Company
Shippingport, Pa.

The Shippingport Atomic Power Station is located on the south bank of the Ohio River in a site consisting of over 400 acres. The site is about 25-miles northwest of Pittsburgh and about 11 miles below the confluence of the Beaver and Ohio Rivers (figure 4). The station is designed to produce electrical energy by a conventional central station type turbine-generator unit. The pressurized water reactor consists of a closed system in which water is circulated by pumps over an array of nuclear fuel elements, or core, contained in a reactor vessel, to heat exchangers where steam is formed in a separate isolated system.

Radioactive waste handled under the environmental program includes liquid and gaseous effluents released into the Ohio River and atmosphere, respectively. The levels of radioactivity released were below Shippingport discharge limits. These limits are based upon radiation standards set forth by AEC's division of Operational Safety in directives published in the AEC Manual[1], and a waste discharge permit from the Pennsylvania Sanitary Water Board.

Ohio River water analysis

During 1968, weekly composite samples were obtained from two continuous automatic samplers in the circulating-water line, upstream and downstream of the radioactive water effluent. Both suspended and dissolved materials in the composite samples were analyzed for gross alpha and gross beta radioactivity. Each composite is also analyzed for potassium-40 content. No significant difference was observed among the average alpha, beta, and potassium-40 radioactivity for the influent and effluent samples. The results of these analyses are presented in table 4.

Ohio River sediment analysis

Once during each calendar quarter, sediment samples of the Ohio River were collected upstream and downstream of the circulating water outfall. These samples were quantitated assuming all detected radioactivity to be cobalt-60, which is the major constituent of radioactive contamination at the station. The results of the sediment samples are presented in table 5. These data indicate that there was no increase of radioactivity in the river sediment as a result of the station's discharges.

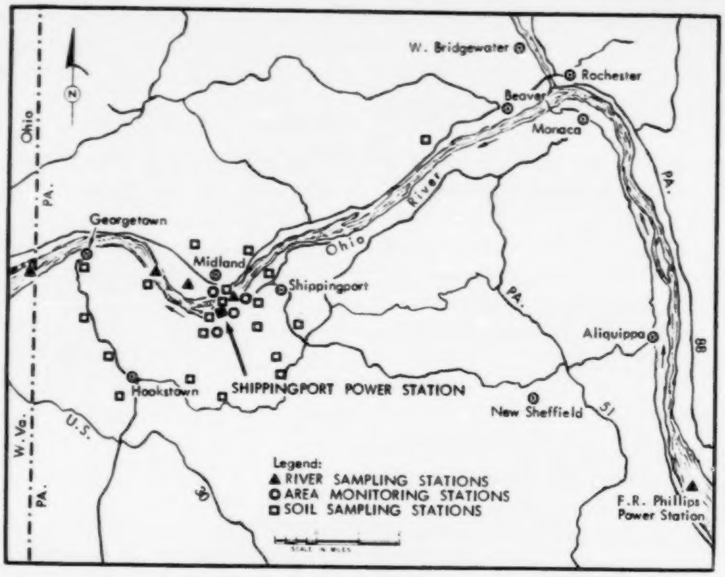
N
W. Bridgewater
Rochester
Beaver
Monaca
Ohio
PA.
Georgetown
Midland
Shippingport
Ohio
River
PA.
PA.
Aliquippa
88
SHIPPINGPORT POWER STATION
Hookstown
New Sheffield
51
U.S.
30
W. Va.
PA.
Legend:
▲ RIVER SAMPLING STATIONS
○ AREA MONITORING STATIONS
□ SOIL SAMPLING STATIONS
F.R. Phillips Power Station
SCALE IN MILES

Figure 4. Shippingport Power Station sampling locations

---

[3] Summarized from "Environmental Radioactivity at the Shippingport Atomic Power Station for the Calendar Year 1968."

Table 4. Gross radioactivity in the Ohio River, Shippingport January–December 1968

Type of radioactive material	Average concentration (pCi/liter)							
	Influent samples				Effluent samples			
	Jan–March	April June	July–Sept.	Oct–Dec.	Jan–March	April–June	July–Sept.	Oct–Dec.
Alpha:								
Total solids	0.89	1.2	0.61	0.83	1.4	1.1	0.84	0.70
Beta:								
Total solids	23	11	17	15	22	18	16	15
Potassium–40	3.2	3.8	6.5	5.7	3.3	3.9	6.6	5.6

Table 5. Total radioactivity in the Ohio River sediment samples, Shippingport, January–December 1968

1968	Number of samples	Gross radioactivity (pCi/g)	
		Upstream	Downstream
January–March	2	6.8	6.7
April–June	2	17	14
July–September	2	7.2	7.3
October–December	2	5.6	6.8

Liquid radioactive waste

The liquid radioactive wastes disposed of at Shippingport are primarily from the reactor coolant system. The radioactive waste produced by the plant is reduced in concentration in such a manner that the concentration of these wastes in water measured at the condenser water stream before discharge to the Ohio River, meets the limits as delineated above. In order to assure that the liquid discharged from the plant will meet specified tolerances, all radioactive waste is collected, processed, and sampled prior to discharge to the environment.

During 1968, a total of 75 mCi gross beta-gamma radioactivity in the liquid waste (exclusive of tritium) and 35 Ci of tritium in liquid waste were released into the environment. The average daily discharge of tritium during this period was 96 mCi. All reported concentrations released to the environment were well below those specified by State and Federal regulations.

Gaseous radioactive waste

Gaseous discharges to the atmosphere, identified as xenon-133, are controlled and released at concentrations less than the MPC of 300 nCi/m^3. During the year 1968, a total of 0.79 millicuries of xenon-133 were released from the plant site at less than the specified concentration.

Film badge monitoring

Twelve film badges for detecting beta-gamma radioactivity were posted continuously at the site perimeter in an attempt to determine the external radiation exposure in the immediate area. In order to accomplish this, a control film badge location was established at a point 10 miles from the station boundary.

During the first and third quarters of this report period, the mrem equivalent taken from the normal quarterly film badges was equal to that of the control film. However, during the second and fourth quarters, differences of readings between the control film and the quarterly site film at several locations ranged up to 20 mrem equivalent. A further check of these differences indicated that they resulted from activities being performed within the controlled area boundary. At no time during this report period was there any significant radiation exposure to the general public outside the facility.

Fallout

Precipitation and fallout are collected in a high-walled pot at one location on the site and analyzed monthly for gross alpha and gross beta radioactivity. A summary of the quarterly average fallout results for 1968 is presented in table 6.

Table 6. Radioactivity in fallout, Shippingport January–December 1968

1968	Deposition rate (nCi/m^2/month)	
	Alpha radioactivity	Beta radioactivity
January–March	0.17	15.03
April–June	.33	9.85
July–September	.15	7.35
October–December	.17	4.51
12-month average	0.20	9.18

Conclusion

From the data presented above, it may be concluded that during 1968 the radioactive effluent releases from the Shippingport station site did not cause any significant increase in background radiation levels. In this regard, the station procedures relative to controlling radioactive discharges to the environment are considered to be effective in protecting the health and safety of the general public.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July–December 1966	July 1967
January–December 1967	February 1969

Reported Nuclear Detonations, September 1969

(Includes seismic signals from foreign test areas)

The U.S. Atomic Energy Commission announced on September 8, 1969 that the United States had recorded seismic signals originating from the southern Ural area. The signals were equivalent to those of a nuclear test in the low (less than 20 kilotons TNT equivalent) yield range.

A Plowshare gas-stimulation experimental nuclear test called Project Rulison was conducted by the Atomic Energy Commission on September 10, 1969. It was a 40-kiloton device detonated near Grand Valley, Colorado.

On September 11, 1969, seismic signals in the Semipalatinsk region also were recorded. The signals were equivalent to those of a nuclear test in the low yield range.

A nuclear test of low yield was conducted September 12, 1969, by the U.S. Atomic Energy Commission at its Nevada Test Site. After the detonation, instruments showed some radiation readings slightly above background. No radioactivity was detected off the test site.

A nuclear text was conducted underground on September 16, 1969 by the Atomic Energy Commission at its Nevada Test Site. It had a yield of less than 1 megaton.

The United States recorded seismic signals on September 22, 1969, which originated in the eastern Tien Shan Mountain Range adjacent to the Chinese nuclear test site of Lop Nor. The signals were equivalent to those of a nuclear test in the low-intermediate yield (20 to 200 kilotons TNT equivalent) range.

On September 26, 1969, seismic signals were recorded by the United States in the Soviet Union, south of Volgograd (Stalingrad). These signals also were equivalent to those of a nuclear test in the low-intermediate yield range.

The United States detected on September 29, 1969, a Chinese nuclear test in the lower atmosphere in the Lop Nor area. The detonation had a yield of about 3 megatons, similar to those of June 17, 1967, and December 27, 1968.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

EXPERIENCE OF THE STATE OF ILLINOIS DEPARTMENT OF PUBLIC HEALTH FOLLOWING THE ENACTMENT OF A LASER SYSTEM REGISTRATION LAW. *R. W. Courtney. Radiological Health Data and Reports, Vol. 10, September 1969*, pp. 421–426.

The experience of the State of Illinois Department of Public Health, following the enactment of a laser registration law, is presented. The priorities suggested for the inspection of laser systems are; (1) high energy laser systems applied in industrial processes; (2) lower energy laser systems used in outdoor processes that could potentially expose the general public; (3) lasers used in research institutions, and (4) lasers used as high school and college teaching instruments. At the time of this report, only one accident had been reported to the Department of Health. This accident was a case of electrical shock in which there was no serious injury or loss of work time for the employee.

Keywords: Accidents, Illinois, industrial, inspection, laser systems, public exposure, registration law, research institutions, teaching institutions.

A COMPARISON OF THE CESIUM-137 CONTENT OF MILK AND PEOPLE FROM 19 DAIRY FARMS IN UTAH, 1962–1966. *R. D. Lloyd, C. W. Mays, R. C. Pendleton, and D. O. Clark. Radiological Health Data and Reports, Vol. 10, September 1969*, pp. 427–433.

Measured cesium-137 concentration (pCi ^{137}Cs/g K) in milk from 19 Utah dairy farms and in residents of those farms, have been compared for the period 1962 through 1966. During the time when cesium-137 levels were increasing (1962–1964), the cesium-137 to potassium ratios in people were similar to the ratios in milk produced by the dairy farm on which they resided. During the time when cesium-137 levels were decreasing (1964–1966) the ratios in people averaged about 2.5 to 4 times higher than the milk. Differences in biological half-times of cesium for men, women, and children, are reflected in their respective body concentrations of cesium-137. This comparison suggests that measured cesium-137 to potassium ratios of milk might be used to estimate the cesium-137 concentration of a population with similar dietary habits during a corresponding time period without considering such factors as milk intake or the consumption of non-milk foods. Preliminary analysis of the relationship between milk levels and body cesium-137 concentration of individual subjects indicates that milk cesium-137 data can be used with appropriate human biological half-times to estimate the shape of human cesium-137/potassium curves for the same time period.

Keywords: Body burdens, cesium-137, dairy farms, milk, potassium, residents, Utah.

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 10, Number 11, November 1969

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Bureau of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Bureau of Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

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- Department of the Interior
- Department of Agriculture
- Department of Commerce
- Department of Health, Education, and Welfare
- Atomic Energy Commission

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Reports

Environmental Survey of Uranium Mill Tailings Pile, Tuba City, Arizona

Southwestern Radiological Health Laboratory[1]
Bureau of Radiological Health

At the request of the Navajo Tribal Council, an environmental radiological survey was conducted on the El Paso Natural Gas Company uranium tailings pile, Tuba City, Arizona, in May 1967. The purpose of the survey was to evaluate potential radiation hazards and to recommend methods of control. The survey included evaluation of external gamma radiation, airborne radioactivity, and waterborne radioactivity.

The results indicate that the external radiation levels on the tailings area exceed recommended exposure limits for individuals in the general population. Wind carriage of the tailings in an easterly direction from the pile has resulted in elevated radiation levels outside the controlled area.

On the basis of these data it was recommended that the mill tailings be properly stabilized against wind erosion or periodic monitoring would be necessary. In May 1968 the pile was regraded and stabilized against wind erosion using a chemical binder. Because of the external radiation levels on the tailings area, this area was not released for public use. It was fenced and posted as a radiation area. The housing area was released to the Navajo Tribe and is presently occupied.

At the request of the Navajo Tribal Council, an environmental radiological survey was conducted on the El Paso Natural Gas Company uranium tailings pile, Tuba City, Ariz., in May 1967 to evaluate potential existing radiation hazards and to recommend methods of control. The site, situated on the Navajo Indian Reservation, Coconino County, Ariz., is leased to the El Paso Natural Gas Company. The uranium mill is approximately 6-miles east of Tuba City, Ariz. (figure 1).

The mill began operation in 1957 (discontinued operation in 1966) and was initially operated by the Rare Metals Corporation with a design processing capacity of 300 tons of ore daily. The mill property is divided into three main areas: the tailings area (including evaporation ponds); the mill area; and the housing area (figure 2).

The tailings area including evaporation ponds, covers an area of about 65 acres. The tailings piles contain an estimated 796×10^3 tons of material with an estimated radium-226 content of 980 pCi/g or a total radium content of approximately 710 g in the tailings material.[2] On the east side of the tailings area material has transgressed the property line because of wind carriage and is readily visible for some 500 feet beyond the property line.

The mill area, covering approximately 30 acres, includes the mill building, shops, miscellaneous buildings, the former stockpile areas, and a scrap area. It is located adjacent to and north of the tailings area.

---

[1] Report written by Mr. Robert N. Snelling, technical project officer, and Dr. S. D. Shearer, Jr., formerly chief, Technical Services, Southwestern Radiological Health Laboratory, Las Vegas, Nev.

[2] Division of Raw Materials, U.S. Atomic Energy Commission, 1967.

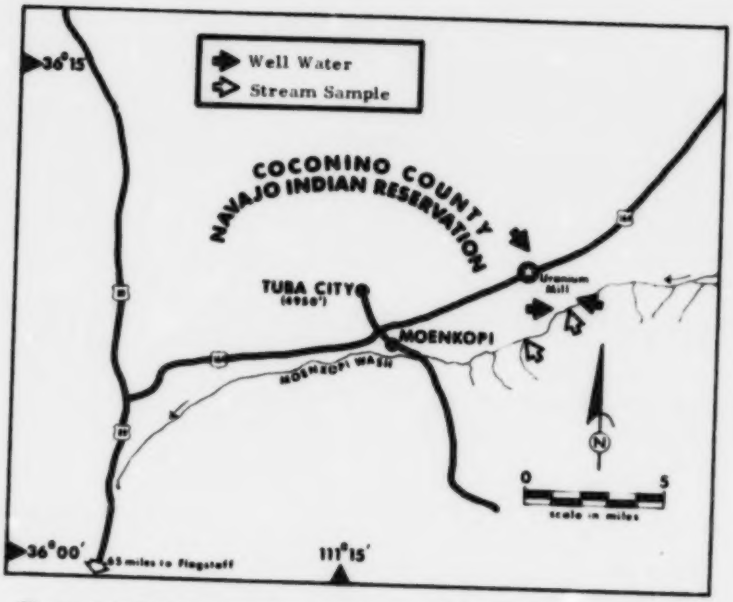
Well Water
Stream Sample
36°15'
COCONINO COUNTY
NAVAJO INDIAN RESERVATION
TUBA CITY
(4950')
Uranium Mill
MOENKOPI
MOENKOPI WASH
N
0
5
scale in miles
36°00'
65 miles to Flagstaff
111°15'

Figure 1. Tuba City uranium mill site and water sampling locations Coconino County, Arizona

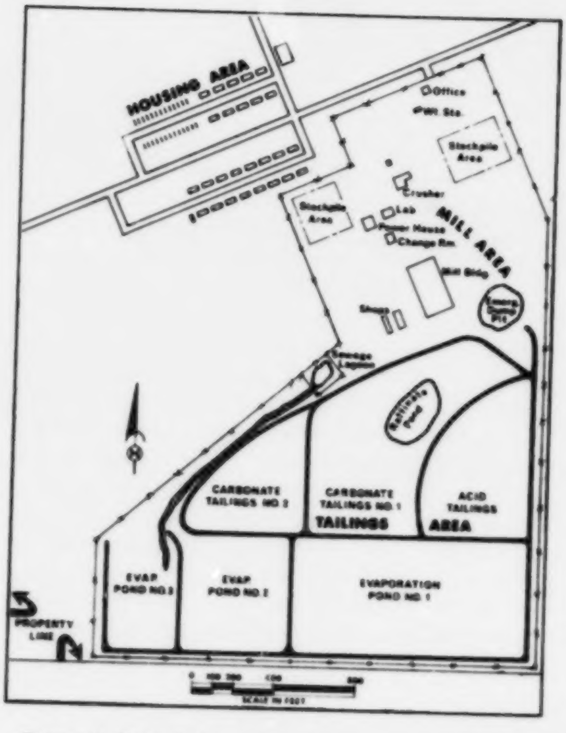
HOUSING AREA
Office
Stockpile Area
Crusher
Stockpile Area
Lab
Power House
Change Rm.
MILL AREA
Mill Bldg
Shops
Sewage Lagoon
CARBONATE TAILINGS NO. 2
CARBONATE TAILINGS NO. 1
ACID TAILINGS
TAILINGS
AREA
EVAP POND NO. 3
EVAP POND NO. 2
EVAPORATION POND NO. 1
PROPERTY LINE
SCALE IN FEET

Figure 2. Tuba City uranium mill, El Paso Natural Gas Company

The housing area is located 1,100 feet north of and about 100 feet higher in elevation than the tailings pile. It consists of 26 houses, a trailer court, and a community building. This area was inhabited by El Paso Natural Gas Company personnel.

Moenkopi wash flows from east to west and is approximately 2-miles south of the mill property. It contains water 11 to 12 months out of the year. The surrounding land is very sparsely populated, although there are several dwellings within one-half mile of the tailings area. The land is utilized primarily for cattle and sheep grazing although some farming is done along Moenkopi wash.

Sampling procedures

External radiation measurements were obtained using a portable Geiger survey meter. Open window (beta-plus-gamma) readings were obtained at the surface and at 3 feet above the surface. The surface readings are assumed to represent beta-plus-gamma radiation whereas the 3-foot readings were shown, by comparison with closed window readings, to be indicative of predominantly gamma radiation. The tailings area was surveyed by laying out an aerial grid and obtaining readings at 200-foot intervals. Measurements in the mill and housing areas were obtained at locations determined to be representative of that area. A total of 170 pairs of readings was obtained.

In addition to the portable instrument readings, thermoluminescent dosimeters (TLD's) were placed at 12 locations on and about the tailings area (figure 3). A beta shield makes the TLD responsive to gamma radiation only. At each location, pairs of dosimeters were exposed for a 4-day period at the surface and the 3-foot level. Three sets of three dosimeters were also placed in Tuba City for background determinations.

There was no observable difference between the survey meter readings at 3 feet (representing beta-plus-gamma radiation) and the TLD readings at 3 feet (representing gamma radiation only), further indicating that most of the radiation measured at 3 feet with the survey meter can be interpreted as gamma radiation.

Airborne particulates were sampled using 0.8μ pore-size membrane filters and a flow rate of 0.75 ft^3/min.

Ten sampling stations were established on or near the tailings area and at one background station in Tuba City (figure 4). Continuous 24-hour samples were obtained at each station on each of 4 consecutive days. These samples were analyzed for radium-226 and long-lived gross alpha and gross beta radioactivity.

A series of 4- to 5-hour continuous air filter samples were obtained (utilizing the same sampling equipment) for the immediate evaluation of the short-lived particulate decay products of radon. Such samples were obtained at each of three locations on four different occasions for a total of 12 samples (figure 4). The filters were examined immediately in the field for alpha radioactivity, utilizing a specially designed alpha-particle scintillation counter in combination with a portable Ludlum scaler and high-voltage supply. The filters were then recounted after radon-222 daughter decay (5 hours) and again after radon-220 daughter decay (5 days). Radon concentrations were then calculated assuming equilibrium between radon and its daughters.

Atmospheric "grab" samples were obtained by means of a specially designed 2-liter flask. The stopcocks of the flask were opened and the

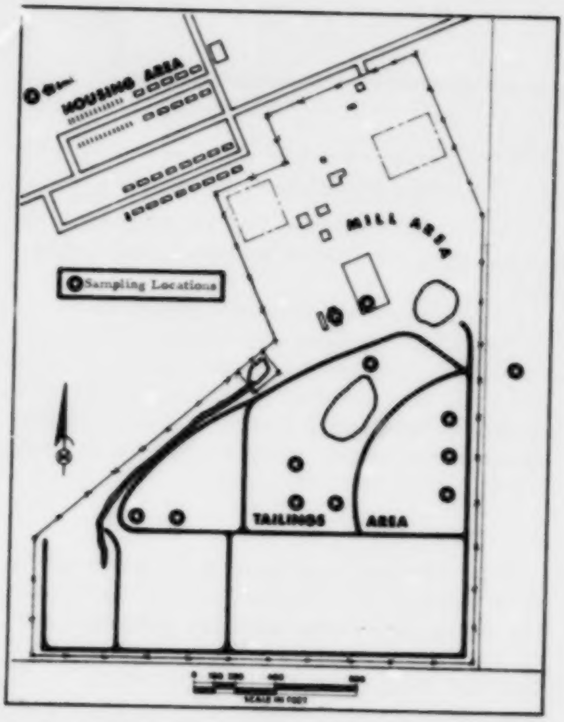

Figure 3. Thermoluminescent dosimeters, Tuba City uranium mill

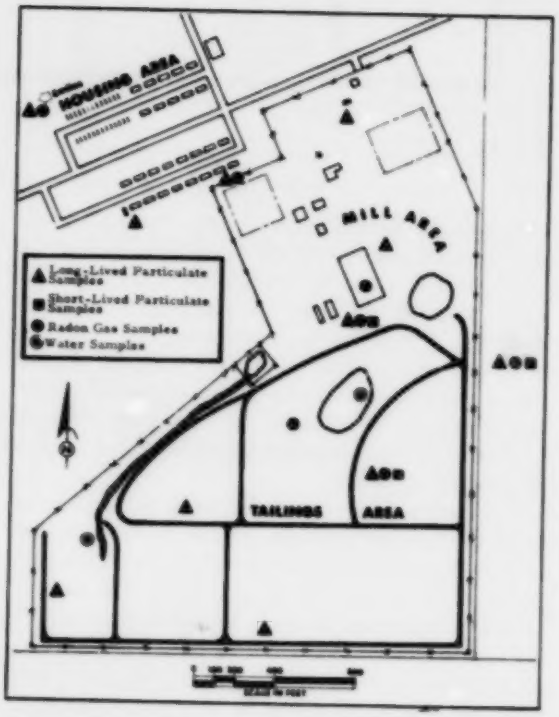

Figure 4. Air and water sampling locations, Tuba City uranium mill

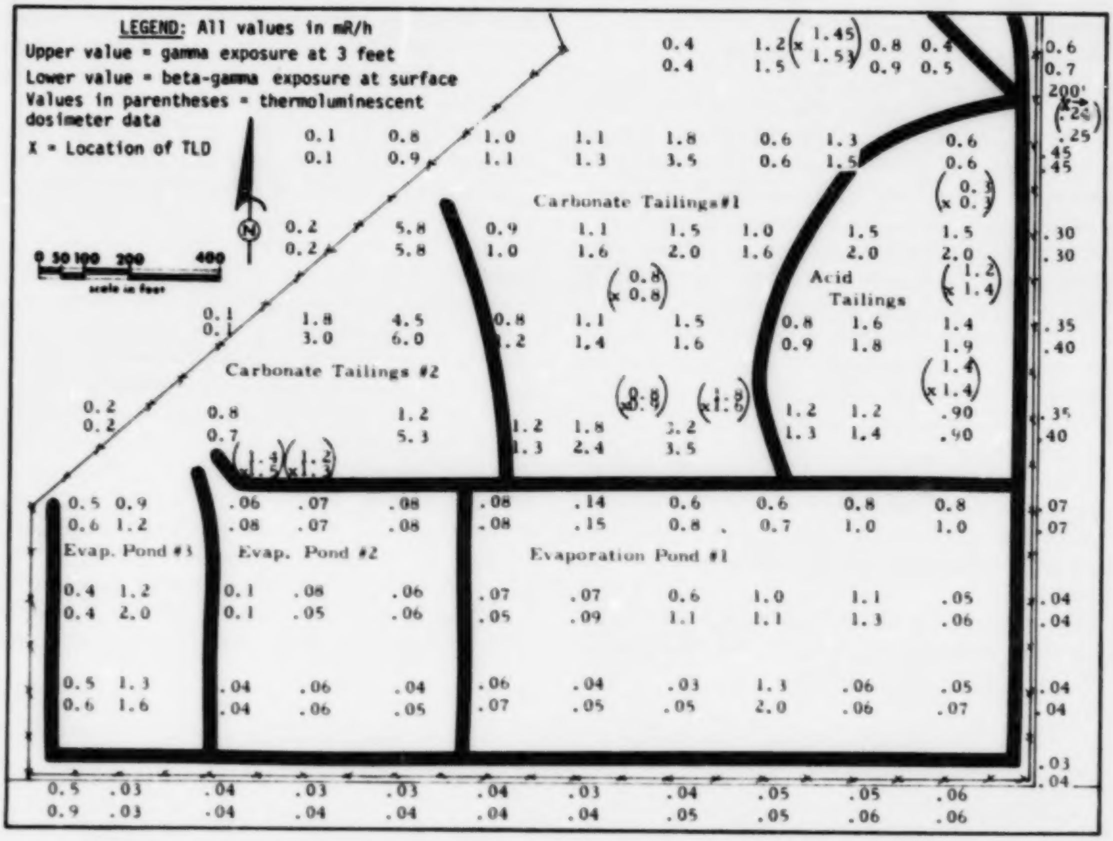
LEGEND: All values in mR/h
Upper value = gamma exposure at 3 feet
Lower value = beta-gamma exposure at surface
Values in parentheses = thermoluminescent dosimeter data
X = Location of TLD
0 50 100 200 400
scale in feet
N
Carbonate Tailings #1
Carbonate Tailings #2
Acid Tailings
Evap. Pond #3
Evap. Pond #2
Evaporation Pond #1
200'

Figure 5. External radiation measurements, Tuba City uranium mill tailings area, May 1967

atmospheric sample was pulled through a 0.8 micron pore-size membrane filter into the flask at the rate of 10 liters per minute for 5 minutes. The flask was allowed to come to atmospheric pressure and the stopcocks were closed. The collected samples were picked up daily by Public Health Service aircraft and flown to Las Vegas for radon-222 analysis. Samples were obtained at four locations on four separate occasions for a total of 16 samples (figure 4).

One-gallon grab samples of water were obtained from the tailings raffinate pond and the municipal sewage lagoon effluent creek which drains onto the tailings area (figure 4). Ground water was sampled at three locations; a shallow well approximately 2-miles southeast of the tailing pile; a shallow well approximately 1-mile south of the pile, and a deep well just north of the mill property (figure 1). Samples were also obtained approximately 1-mile upstream and 1.5-miles downstream on Moenkopi wash. The water samples were analyzed for gross alpha and gross beta radioactivity, and radium-226.

All laboratory analyses were performed at the Southwestern Radiological Health Laboratory (SWRHL). After sample preparation, gross alpha and gross beta radioactivity determinations were performed by counting directly in an end-window, gas-flow proportional counter. Radium-226 was determined by radon emanation.

Meteorology

Wind direction and speed were estimated by visual observation. The predominant wind direction at the mill site for the 4-day sampling period was from the west. This is the predominant wind direction throughout the year according to El Paso Natural Gas Company officials. During the second through fourth day of the survey, strong winds (estimated at 15 to 30 mph) were encoun-

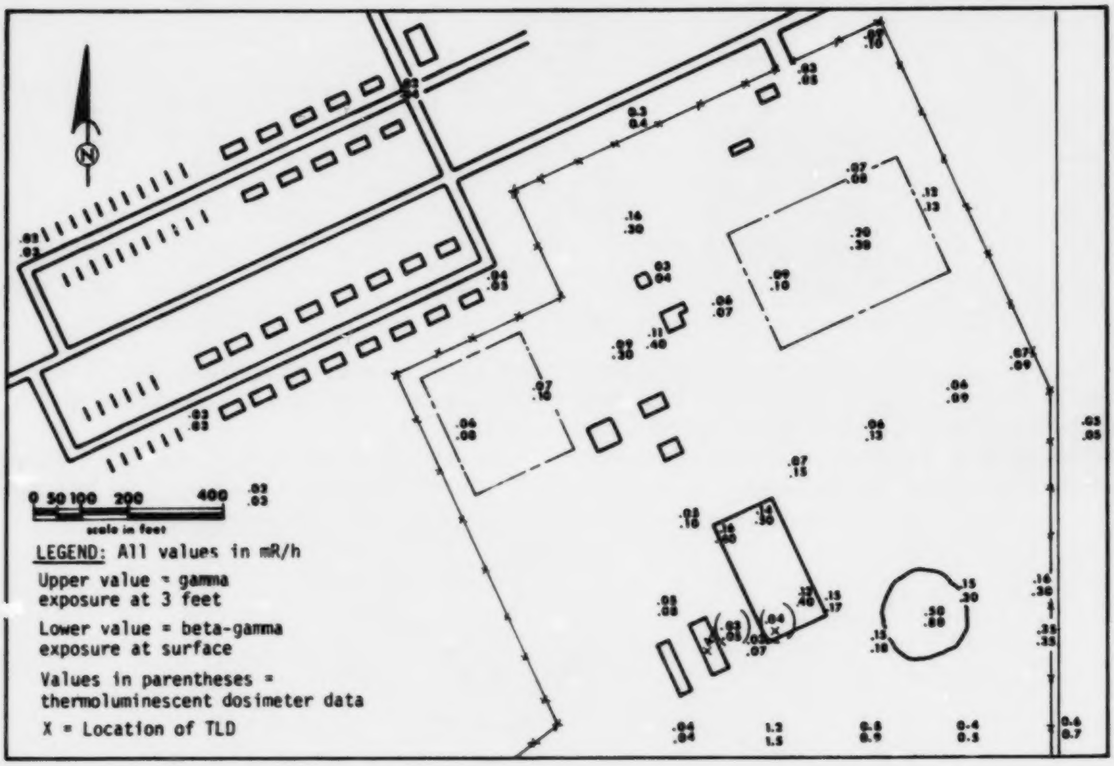
N
0 50 100 200 400
scale in feet
LEGEND: All values in mR/h
Upper value = gamma exposure at 3 feet
Lower value = beta-gamma exposure at surface
Values in parentheses = thermoluminescent dosimeter data
X = Location of TLD

Figure 6. External radiation measurements, Tuba City uranium mill and housing areas, May 1967

tered throughout the daylight hours. This resulted in heavy dust carriage downwind from the pile. The wind conditions encountered during the major part of the sampling period were most likely not representative of the average wind conditions throughout the year, even though such winds are frequent in that area. The data obtained must be interpreted with this in mind.

Results—external radiation

To evaluate the potential long-range hazard associated with the external radiation emitted from the tailings material, the average yearly whole-body exposure for an individual having a 24-hour-per-day residence in the area was calculated and compared to the recommended RPG of 0.5 rem/yr (*2*). Only the gamma radiation at 3 feet was used for this computation.

Table 1 summarizes the results obtained from the portable instrument survey on each unique area and the average values for composite areas. Figures 5 and 6 indicate the location and magnitude of the individual measurements at the surface and at 3 feet above the surface.

The background radiation level in the surrounding area was found to average 0.02 mR/h both at the surface and at 3 feet above the surface. This level of radiation is negligible in comparison to the order of magnitude of radiation measured on and about the tailings area and is therefore neglected.

The radiation exposure at the 3-foot level on the tailings area ranged from a maximum of 5.8 mR/h on carbonate pile No. 2 to a minimum of 0.03 mR/h along the south fence. The average for the area was 0.7 mR/h. The surface exposures ranged from 6 mR/h to 0.02 mR/h with an average of 0.9 mR/h. A plot of isoradiation lines depicting the relative radiation levels at 3 feet over the mill property is given in figure 7.

The average whole-body dose for an individual having a 24-hour-per-day residence on the tailings area, was computed to be approximately 6.0 rem/

Table 1. External radiation measurements, Tuba City uranium mill, May 1967

Area	Location	Number of measurements	mR/h at surface			mR/h at 3 feet		
			High	Low	Average	High	Low	Average
Tailings	Evaporation pond 1	18	2.0	0.05	0.5	1.3	0.03	0.4
Tailings	Evaporation pond 2	9	.1	.04	.06	.1	.04	.07
Tailings	Evaporation pond 3	6	2.0	.4	1.1	1.3	.4	.8
Tailings	Acid pile	9	2.0	.6	1.4	1.6	.6	1.2
Tailings	Carbonate pile no. 1	19	3.5	.4	1.5	3.2	.4	1.2
Tailings	Carbonate pile no. 2	10	6.0	.1	2.4	5.8	.1	1.6
Tailings	East fence	9	.7	.04	.2	.6	.03	.2
Tailings	South fence	11	.9	.03	.1	.5	.03	.08
Tailings	Composite area	91	6.0	.03	.9	4.5	.03	.7
Mill	Mill area	27	.8	.04	.2	.5	.03	.4
Mill	Mill building	3	.5	.4	.4	.2	.1	.1
Housing	Housing area	5	.05	.03	.04	.04	.02	.03
Background	Tuba City	10	.04	.02	.02	.04	.02	.02

a based on an average radiation exposure of 0.7 mR/h. This dose is 12 times the Radiation Protection Guide (RPG) of 0.5 rem/a (*2*). The whole-body dose for an individual in a non-radiation occupation working 40-hours-per-week on the tailings area would be approximately 1.5 rem/a. This is nearly three times the recommended RPG of 0.5 rem/a.

Significant tailings material had shifted across the property line on the east side of the pile. The

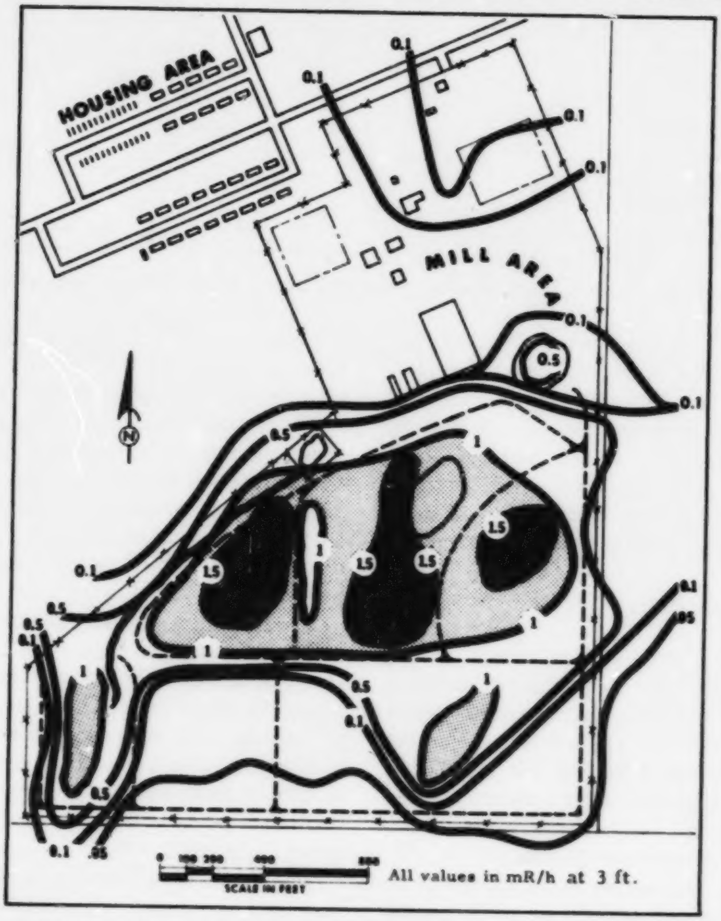

Figure 7. External gamma radiation levels, Tuba City uranium mill, May 1967

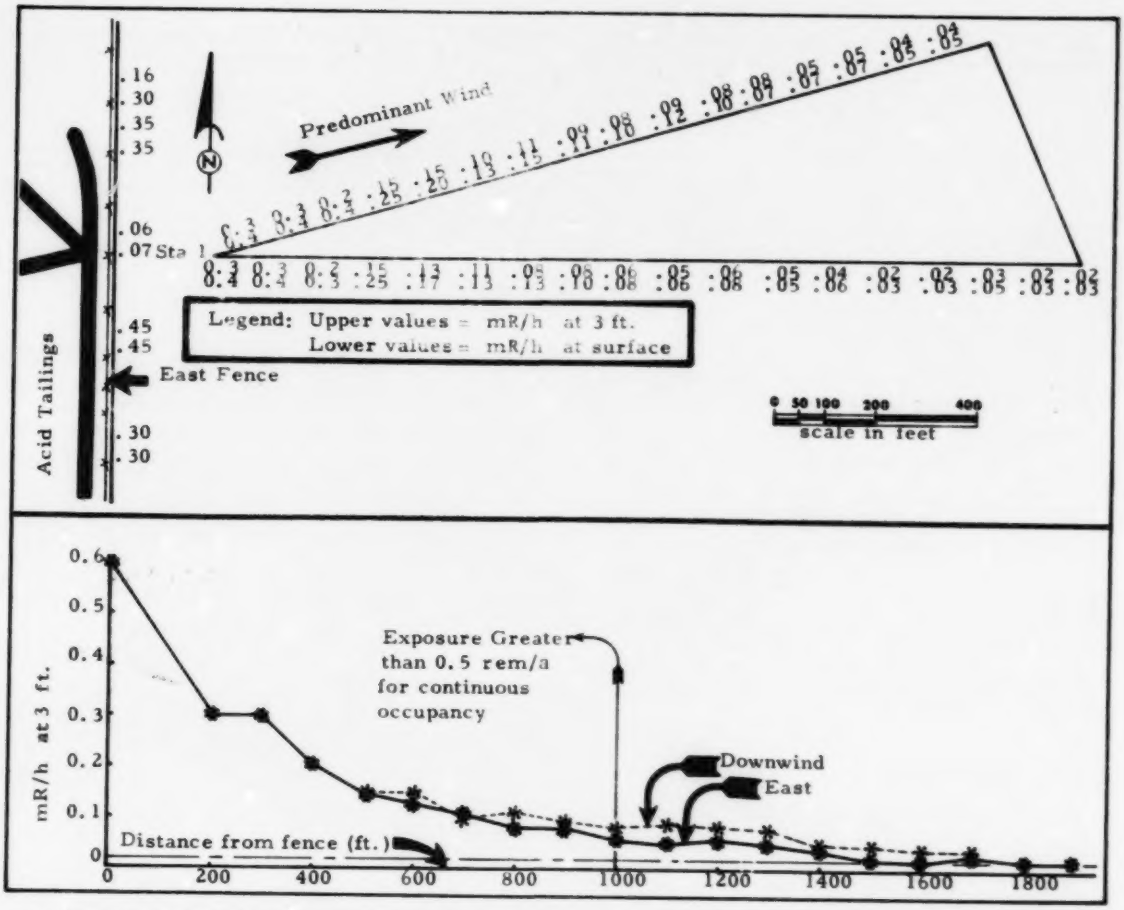

Figure 8. External radiation vs. distance downwind from tailings pile, Tuba City uranium mill, May 1967

exposure at the 3-foot level ranged from 0.6 mR/h at the property line to 0.02 mR/h 1,600-feet downwind from the property line. Permanent 24-hour occupancy within 1,000-feet east of the fence adjacent to the acid tailings would result in an annual average dose equal to or greater than the RPG of 0.5 rem/a (figure 8).

The average radiation exposure at 3 feet above the surface around the mill area was 0.1 mR/h. The distribution of measurements can be seen in figures 6 and 7. The average dose to an individual having a 24-hour per day residency in this area, on the basis of the average value of 0.1 mR/h is 0.9 rem/a. Although this dose is approximately twice the RPG of 0.5 rem/a, it represents a highly unlikely condition of continuous occupancy. With reasonable occupancy assumptions it would not be expected that an annual average dose in excess of 0.5 rem would occur.

The radiation exposure at 3 feet above the surface in the housing area was found to average 0.03 mR/h. This exposure represents essentially background levels of radiation. The average whole-body dose for an individual having 24-hour-per-day residence in this area is computed to be about 0.07 rem/a from that radiation over and above background. This is approximately 15 percent of the RPG of 0.5 rem/a.

A summary of the results obtained from the thermoluminescent dosimeters placed about the tailings area is shown in table 2. The results in general are in good agreement with the portable instrument survey indicating levels of the same order of magnitude (table 3).

Table 2. External radiation measurements utilizing thermoluminescent dosimeters, Tuba City uranium mill, May 1967

Area	Number of measurements	External gamma radiation (mR/h)	
		Surface	3 feet
Acid tailings	3	1.0	1.0
Carbonate tailings No. 1	4	1.2	1.2
Carbonate tailings No. 2	2	1.4	1.3
Mill building	1	—	.04
Shops	1	.05	.03
Background	3	—	.01

Table 3. External radiation measurements, comparison of thermoluminescent dosimeters to portable surveymeter measurements, Tuba City uranium mill May 1967

Area	Surface radiation (mR/h)		Radiation at 3 feet (mR/h)	
	TLD[a]	Survey meter[b]	TLD[a]	Survey meter[b]
Acid tailings	1.0	1.4	1.0	1.1
Carbonate tailings No. 1	1.2	1.9	1.2	1.6
Carbonate tailings No. 2	1.4	1.4	1.3	1.0
Mill building	—	—	.04	—
Shops	.05	.07	.03	.04
Background	—	.02	.01	.02

[a] Values represent gamma radiation.

[b] Values represent the average beta-gamma radiation measured in the same vicinity as the TLD's.

Results—air sampling

In order to assess the potential long-range health hazard associated with the inhalation of airborne radionuclides, the average radioactivity concentration observed for each sampling station during the 4 days of sampling is compared to the recommended radiation concentration guides (*1*). Because the concentration guides are applicable to yearly average concentrations, this comparison assumes that the meteorological conditions imposed during the sampling period are representative of the yearly average conditions. Interpretation of the levels of radioactivity observed during the survey as representative of yearly average concentrations must therefore be interpreted as being a conservative approach.

The gross alpha radioactivity found on 24-hour continuous filter samples taken on and near the tailings are shown in table 4. The background level (Tuba City) was found to average 0.007 pCi/m³ for 4 days of sampling. The average station results ranged from about 2 to 1,900 times the average background level. Figure 9 shows the average gross alpha radioactivity found at each station. It is noted that the radioactivity concentrations are higher on the tailings area than in the housing or mill areas and that the values downwind from the tailings area are higher than those upwind.

Table 4. Gross long-lived alpha particulate activity in air, Tuba City uranium mill, May 1967

Station	Concentration (pCi/m³)				
	May 8–9	May 9–10	May 10–11	May 11–12	Weighted average
1	12	—	15	12.6	13.2
2	0.18	0.14	0.16	0.06	0.14
3	.15	.15	.02	.12	.11
4	.05	[a] < .004	[a] < .004	[a] < .004	.015
5	.03	[a] < .004	.15	.40	.15
6	.11	.69	.41	.28	.36
7	1.3	9.5	8.4	6.7	6.7
8	—	.14	—	—	.14
9	—	—	—	—	—
10	.18	.23	.47	.70	.40
Background	0.010	[a] <0.004	0.007	0.007	0.007

[a] Less than figures used as absolute values in averaging.

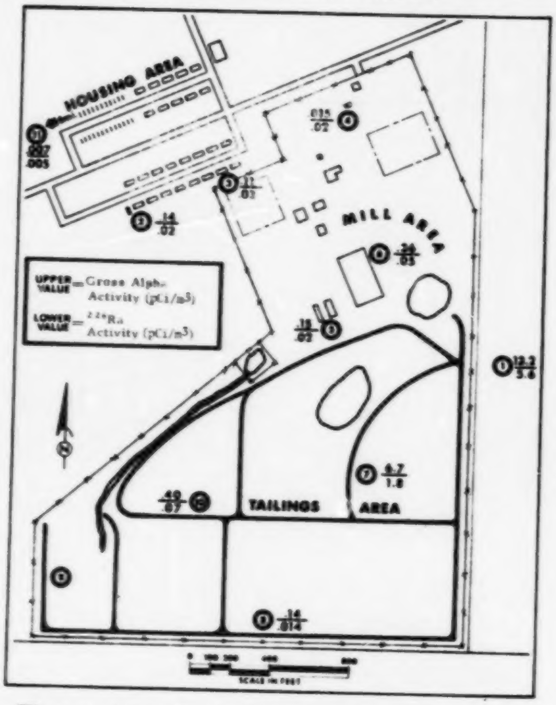

Figure 9. Long-lived airborne particulate activity, Tuba City uranium mill, May 1967

The Code of Federal Regulations (*1*) indicates a concentration guide for unidentified natural radionuclides in air of 0.08 pCi/m³ (when protactinium-231 is assumed absent). All stations on and in the immediate vicinity of the tailings pile except station 4, displayed gross alpha radioactivity in excess of the concentration guide for unidentified radionuclides. This indicates that identification of the specific radionuclides contributing to the total alpha radioactivity is necessary in order to evaluate the potential long range health hazard associated with the inhalation of the airborne particles.

Results—radium-226

Table 5 indicates the radium-226 concentrations determined by analyzing 24-hour samples at each station. The average concentration for each station ranged from about three to 1,000 times the average background. Figure 9 indicates the average radium-226 concentration at each station. In order to assess the potential long-range health hazard associated with the inhalation of radium in air, the concentrations observed are compared to the concentration guide of 2 pCi/m³ (*1*).

Table 5. Radium-226 activity in air, Tuba City uranium mill, May 1967

Station	Concentration (pCi/m³)				
	May 8–9	May 9–10	May 10–11	May 11–12	Weighted average
1	3.6	—	9.95	3.1	5.6
2	0.015	0.02	0.02	0.06	0.02
3	.04	.03	.01	.04	.03
4	[illegible]	.002	.01	.01	.02
5	[illegible]	.007	.03	.04	.02
6	.02	.10	.03	.04	.05
7	.13	2.2	2.9	1.6	1.8
8	—	.014	—	—	.014
9	—	—	—	—	—
10	.02	.04	.10	.11	.07
Background	0.006	0.007	0.004	0.004	0.005

The average radium-226 concentration for samplers 2, 3, and 4, located in the housing area was 0.02 pCi/m³. This represents a level equal to 1/100 of the recommended concentration guide (*1*).

The average radium-226 concentration for stations 5 and 6 is 0.035 pCi/m³. This level of radioactivity represents approximately 1/60 of the recommended concentration guide (*1*).

The average radium-226 values for individual sampling stations on the tailings area and downwind from the tailings area ranged from a low of 0.014 pCi/m³ to a high of 5.6 pCi/m³. Station 7 which was located on the acid tailings and which was subjected to a significant dust loading displayed a radium activity concentration of 1.8 pCi/m³ which is nearly equal to the recommended concentration guide of 2 pCi/m³. Station 1, located 200 feet east and in the predominant downwind direction indicated an average radium-226 concentration of 5.6 pCi/m³ or 2.8 times the concentration guide.

It is evident that substantial transport of radium-226 is occurring in the downwind direction and that concentrations in excess of recommended concentration guides are occuring.

Results—other radionuclides

Of the other radionuclides in the natural uranium decay chain, the most significant as potential health hazards are the alpha-particle emitters. These radionuclides and their appropriate concentration guides are:

Thorium-230, soluble	0.08 pCi/m³
Natural uranium, insoluble	2 pCi/m³
Lead-210, soluble	4 pCi/m³
Polonium-210, insoluble	7 pCi/m³

It is seen that thorium-230 represents the most restrictive radionuclide in terms of recommended concentration guides.

The physical pickup and transport of material from the pile should theoretically produce the same relative distribution of radionuclides in downwind air as found in the tailings pile itself (assuming a homogeneous pile). For complete equilibrium through the uranium series, a gross alpha radioactivity to radium-226 ratio of 8 to 1 should exist. Because the uranium series is most likely not in complete equilibrium, and because there will be some contribution from the natural actinium and thorium series, some variance in the gross alpha radioactivity to radium-226 ratio can be expected.

Table 6 depicts the gross alpha radioactivity to radium-226 ratios found for each 24-hour filter sample. The ratio ranged from approximately 1 to 12, with an average ratio of 4.9. This indicates that normal ratios of radium-226 to gross alpha radioactivity were encountered. It is therefore reasonable to expect that the ratio of other individual radionuclides in the decay series to gross alpha radioactivity will be of the same order of magnitude.

Table 7 indicates the magnitude of the average unidentified alpha radioactivity (gross alpha radioactivity minus radium-226) for each sampling station. It is noted that even if all of the unidentified alpha radioactivity is attributed to thorium-230 (a highly conservative assumption)

Table 6. Gross alpha to radium-226 ratios, long-lived airborne particulate activity, Tuba City uranium mill, May 1967

Sample number	Gross alpha (pCi/m^3)	Radium-226 (pCi/m^3)	Gross alpha / radium-226
11	12.0	3.60	3.3
13	15.0	9.95	1.5
14	12.6	3.10	4.1
21	0.18	0.015	12.0
22	.14	.02	7.0
23	.16	.02	8.0
24	.06	.06	1.0
31	.15	.04	3.7
32	.15	.03	5.0
33	.02	.01	2.0
34	.12	.02	6.0
41	.05	.06	[a].8
42	< .004	.002	2.0
43	< .004	.01	[a].4
44	< .004	.01	[a].4
51	.03	.004	7.5
52	< .004	.007	[a].6
53	.15	.03	5.0
54	.40	.04	10.0
61	.11	.02	5.5
62	.69	.10	6.8
63	.41	.04	10.2
64	.28	.05	5.6
71	1.30	.13	10.0
72	9.50	2.20	4.3
73	8.40	2.90	2.9
74	6.70	1.60	4.2
82	.14	.014	10.0
101	.18	.02	8.0
102	.23	.04	5.7
103	.47	.10	4.7
104	.70	.11	6.4
111	.01	.006	1.7
112	< .004	.007	[a].6
113	.007	.004	1.8
Average			4.9

Assumed to equal 1.00 for averaging.

Table 7. Unidentified alpha particulate activity in air Tuba City uranium mill, May 1967

Sampling station	Unidentified alpha (pCi/m^3)
1	7.60
2	0.12
3	.08
4	0
5	.13
6	.31
7	4.90
8	.12
9	—
10	.33
11	.002

only stations 1, 6, 7, and 10, significantly exceed the concentration guide of 0.08 pCi/m^3. If it is estimated that thorium-230 comprises approximately one-fifth of the unidentified alpha radioactivity (as estimated from the corresponding alpha to radium ratio), only stations 1 and 7 exceed the concentration guide of 0.08 pCi/m^3 for thorium-230.

It is thus concluded that since thorium-230 is the limiting radionuclide, no other radioisotopes of the uranium series will exceed their appropriate concentration guide except directly on the pile and directly downwind from the pile.

It must be assumed, however, that concentrations directly downwind from the pile will exceed the concentration guide for thorium-230 as well as for radium-226. Even if the thorium-230 comprised only 1/10 of the unidentified alpha radioactivity (most likely an underestimate), the radioactivity at station 1 would be 0.76 pCi/m^3 which is a factor of 10 greater than the appropriate guide.

Results—radon gas

Table 8 summarizes the radon-222 concentrations found at various sampling times and locations. Figure 10 represents the average radon concentrations at each sampling location.

All samples were obtained under unstable atmospheric conditions with predominantly strong westerly winds. Under these conditions it can be expected that atmospheric radon concentrations will be minimal due to atmospheric dilution.

The radiation concentration guide for radon-222 in air in unrestricted areas is 3 pCi/liter (*1*).[3] To

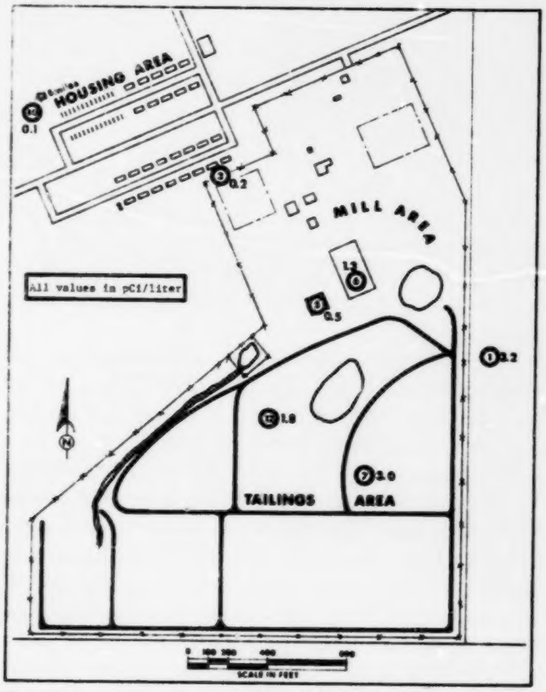

Figure 10. Atmospheric radon-222, Tuba City uranium mill, May 1967

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[3] The daughters of radon-222 are assumed present to the extent that they occur in unfiltered air.

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Table 8. Radon gas radioactivity concentration in air[a], Tuba City uranium mill, May 1967

Date	Time	Background	Radon-222 (pCi/liter)					
			Station 1	Station 3	Station 5	Station 6	Station 7	Station 12
May 9	0800	—	6.2	—	—	1.3	6.1	2.3
May 9	1900	—	1.8	—	—	1.4	2.9	1.3
May 11	0800	0.1	—	0.2	—	.12	2.1	—
May 12	0800	—	1.6	—	0.5	1.3	1.0	—
Average		0.1	3.2	0.2	0.5	1.3	3.5	1.8

[a] Atmospheric stability for all stations was "lapse."

evaluate the potential long-range hazard associated with the inhalation of radon and its progeny, the atmospheric radon concentrations are compared to this guide.

A single background sample was obtained in Tuba City and indicated a radon concentration of 0.1 pCi/liter.

The tailings area displayed radon concentrations averaging 1.8 pCi/liter to 3.5 pCi/liter. These values exceed background levels by approximately an order of magnitude. Stations 1 and 7 averaged slightly above the concentration guide of 3.0 pCi/liter.

It is significant that the samples were obtained under unusual atmospheric conditions. Under more stable conditions, higher values might be expected. Furthermore, if structures were built upon the radon-emanating material, the radon concentrations inside the structures would be expected to increase.

Radon concentrations within the mill building averaged 1.3 pCi/liter. Again, this is an order of magnitude greater than background but only 42 percent of the recommended concentration guide of 3.0 pCi/liter. One outside sample was obtained in the mill area and indicated a radon concentration of 0.5 pCi/liter, approximately one-sixth of the concentration guide. It does not appear, based on these very limited data, that a radon problem exists in the mill area.

One radon sample was obtained at the housing area and was not significantly above background.

The concentrations of radon-222 gas as calculated from radon daughter products, assuming equilibrium, are shown in table 9. It is noted that the radon-222 concentrations average approximately 1/10 to 1/100 of the radon as determined directly by gas sampling. It is therefore apparent that secular equilibrium assumed in the calculations relating radon daughter products to radon gas does not exist. These conditions make the equations invalid and subsequently little quantitative interpretation can be made of the data except to say that a low percentage of secular equilibrium existed.

Table 9. Atmospheric radon as calculated from radon progeny, Tuba City uranium mill, May 1967

Date	Time	Radon-222 (pCi/liter)		
		Station 1[a]	Station 7[b]	Station 5[c]
May 9	1900	0.026	0.054	0.036
May 10	1330	lost	.043	.012
May 11	1440	0.053	.034	.018
May 12	1200	lost	.091	.068
Average		0.040	0.056	0.034

[a] Station 1, 200 feet east of east fence.
[b] Station 7, acid tailings.
[c] Station 5, shop area.

Results—water sampling

The gross alpha and gross beta radioactivity, and radium-226 concentrations found in water samples are shown in table 10. The background levels were obtained from a deep well north of the tailings area.

Samples taken from two shallow wells approximately 1 to 2 miles from the tailings area showed background levels of radioactivity. Based on these

Table 10. Waterborne radioactivity, Tuba City uranium mill, May 1967

Location	Radioactivity concentration (pCi/liter)		
	Gross alpha	Gross beta	Radium-226
Tailings raffinate pond	5,300	89,700	1,200
Sewage lagoon overflow	160	200	87
Ground water, 2 miles southeast	0.8	2	0.15
Ground water, 1 mile south	.6	3	.59
Moenkopi wash, 1 mile upstream	.8	11	.28
Moenkopi wash, 1.5 miles downstream	.4	3	.28
Ground water, 0.25 miles north (background)	1.4	7	.22

limited data, it does not appear that ground water contamination has resulted from leaching of radioactivity from the pile.

The Moenkopi wash both upstream and downstream from the tailings pile showed background levels of radioactivity.

The radioactivity concentrations of the raffinate pile and sewage lagoon overflow were several orders of magnitude above background. Both bodies of water are contained entirely within the controlled area of the mill and therefore do not represent an immediate problem as long as the area is restricted.

Summary

External gamma radiation on the tailings area averaged 0.7 mR/h at 3 feet above the surface, which calculates to an average dose of 6.0 rem/a for continuous exposure. This exceeds by a factor of 12 the currently recommended Radiation Protection Guide of 0.5 rem/a for continuous whole body exposure to individuals in the general population. These findings serve to preclude the release of the tailings area for public use. Action which would permit release of said area would be to cover the tailings with uncontaminated dirt to an extent that would diminish the external radiation to an acceptable level and to stablilize the covering against wind erosion. Otherwise, the area should be fenced and controlled as a radiation area.

The property extending east of the tailings area, beyond the mill property line, in the direction of the predominant westerly winds shows significant external radiation resulting from transported tailings material. The radiation exposure at 3 feet above the surface in this area to a distance of 1,000 feet from the property line was high enough to result in an average dose equal to or greater than the RPG of 0.5 rem/a for continuous exposure. Permanent residence in this area should be prohibited.

The mill area exhibited external gamma radiation levels averaging 0.1 mR/h at 3 feet above the surface. This calculates to an annual average dose of 0.9 rem for continuous exposure which is approximately two times the appropriate RPG of 0.5 rem/a. With reasonable occupancy assumptions, however, the annual average dose would probably not exceed 0.5 rem.

The housing area displayed background levels of external radiation.

Significant airborne transport of tailings material east of the mill property is clearly demonstrated by visual identification of tailings material in this area as well as by the elevated gamma radiation levels.

The radioactivity concentration of radium-226 in air at station 1,200 feet east of the property fence averaged 5.6 pCi/m^3. This represents a radioactivity concentration in excess of the appropriate concentration guide for insoluble radium-226 of 2 pCi/m^3 by a factor of 2.8. Furthermore, it was estimated that thorium-230 also exceeded its applicable concentration guide by a factor of about 10. It must be concluded that concentrations of radium-226 and thorium-230 will exceed recommended concentration guides in the downwind direction from the pile if it remains uncovered and unstabilized. If habitiation of this area is to be allowed, stabilization of the tailings pile against wind erosion will be necessary.

The gross alpha and radium-226 activity in air in the mill and housing areas were well below the applicable radiation concentration guides.

Radon gas concentrations on the tailings area averaged from 1.8 pCi/liter to 3.5 pCi/liter for the samples taken. These levels are approximately equal to the guide of 3.0 pCi/liter. It should be pointed out that this guide is applicable to radon-222 and its daughters as they occur in unfiltered air. This may be interpreted as meaning radon in equilibrium with its daughter products in air. Since it was demonstrated that equilibrium did not exist between radon and its progeny at least at the time of daughter product sampling, it does not appear that the guide has been exceeded. Levels of radon-222 in the mill and housing areas are substantially below the recommended guide.

It should be emphasized that if enclosed structures were to be built on the tailings material, a substantial increase in radon concentration would occur within the structure and the concentration guide may be exceeded. This applies not only to the tailings pile but also to the substantial volume of tailings material which has already been transported outside the mill property east of the pile.

There is no evidence from current data that surrounding ground or surface water has been affected by the leaching of radioactive materials from the tailings area.

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On the basis of the data gathered in this survey it was recommended that the mill tailings be properly stabilized against wind erosion. This action would preclude further carriage of tailings material into the surrounding environment and would eliminate the potential long-term hazard to anyone inhabiting the area downwind from the mill property.

As a result of the external radiation levels on the tailings area, this area should not be released for public use in its present state. Action which would permit release of the area would be to cover the tailings with uncontaminated dirt to an extent that would diminish the external radiation to an acceptable level and to stabilize the covering against wind erosion.

Followup

This study was conducted as part of the Uranium Mill Tailings Project being conducted at the Southwestern Radiological Health Laboratory. The objectives of the project are to gather information on the potential health hazards associated with uranium mill tailings and to institute control action where necessary.

The recommendations herein were presented to the Navajo tribe and to the State of Arizona in October 1967. In November 1967, the State of Arizona directed the El Paso Natural Gas Company to stabilize the pile against wind erosion and to fence and post the property to prevent access by unauthorized people.

El Paso Natural Gas Company, in cooperation with the U.S. Bureau of Mines' Metallurgy Research Center, regraded, fenced and chemically stabilized the pile against wind erosion in May 1968 (*3*). The housing area was released to the Navajo tribe and is presently occupied.

An inspection of the tailings area in May 1969 indicated that the chemical binder had maintained its integrity.

Mention of commercial products is not to be construed as an endorsement by the Public Health Service.

REFERENCES

(*1*) Title 10, Code of Federal Regulations, Part 20, Standards for Protection Against Radiation.

(*2*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*3*) U.S. BUREAU OF MINES. Chemical Stabilization of the Uranium Tailings at Tuba City, Ariz., U.S. Bureau of Mines No. 7288 (August 1969).

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Data

SECTION I. MILK AND FOOD

Milk Surveillance, July 1969

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation and/or corrective public health action.

The Pasteurized Milk Network, (PMN) sponsored by the Bureau of Radiological Health and the Bureau of Compliance, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Public Health Service)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that occur in or are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means

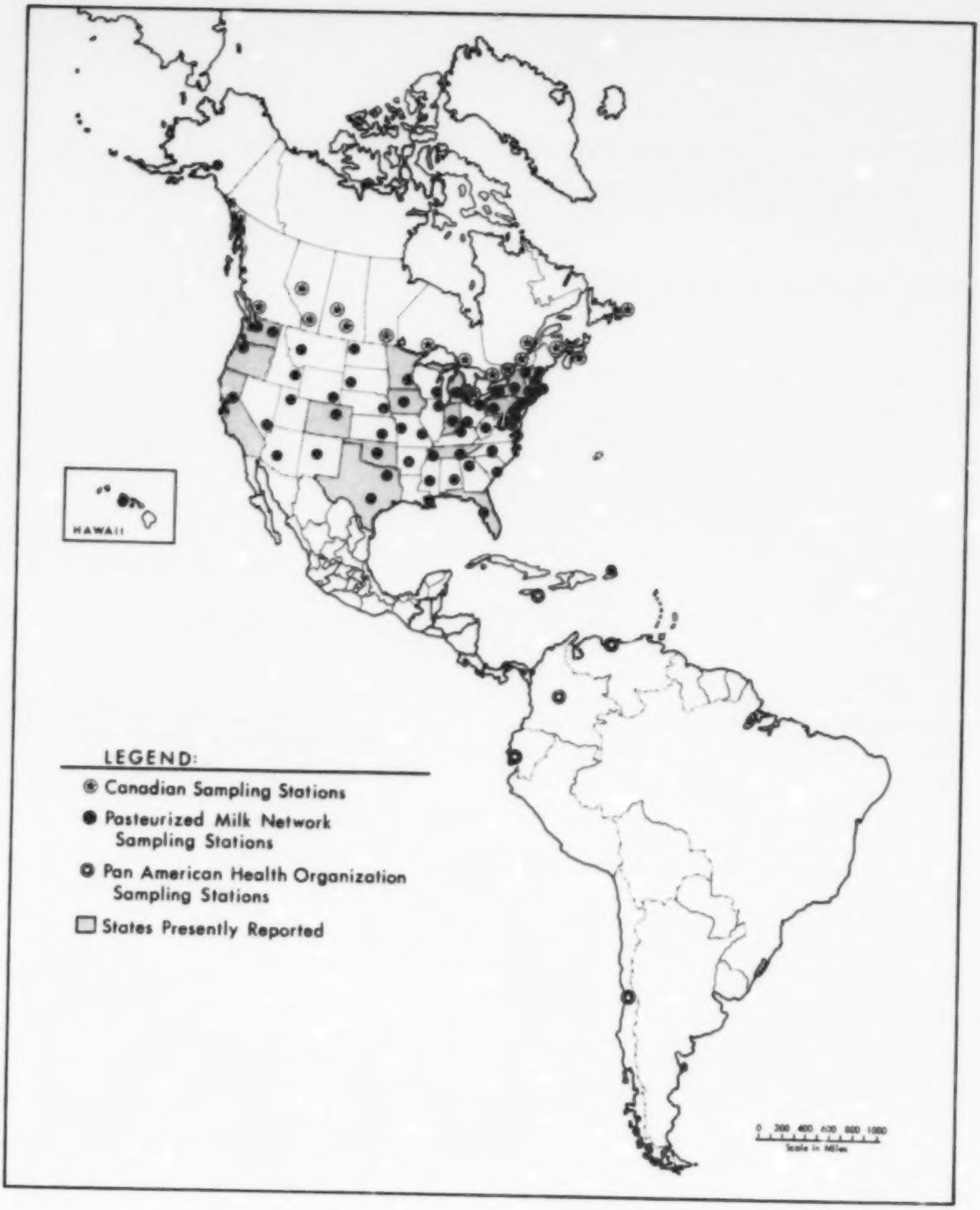
HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
○ Pan American Health Organization Sampling Stations
☐ States Presently Reported
0 200 400 600 800 1000
Scale in Miles

Figure 1. Milk sampling networks in the Western Hemisphere

for assessing the biological behavior of metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variation, expressed in terms of 2-standard deviations, for these concentrations are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for the period, May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Bureau of Radiological Health conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted in December 1968, with 37 laboratories participating in an experiment on milk samples containing known concentrations of strontium–89, strontium–90, iodine–131 and cesium–137. Of the 19 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 18 participated in the experiment.

In general, the results for iodine–131 and cesium–137 are encouraging, but the results for strontium–89 and strontium–90 need improvement (*5*). Keeping these possible differences in mind, integration of the data from the various networks can be undertaken without introducing a serious error due to disagreement among the independently obtained data.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methodologies, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium–40, iodine–131, cesium–137, and barium–140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A recent article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data articles for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. The frequency of collection and analysis varies not only among the networks, but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium–90 and cesium–137 are relatively constant over short time periods and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine–131, the frequency of analysis is critical, and is generally increased at the first measurement or recognition of a new influx of the radionuclide.

The data presentation also reflects whether raw or pasteurized milk was collected. A recent analysis (*7*) of raw and pasteurized milk samples collected during the period, January 1964 to June 1966, indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant. Particular attention was paid to strontium–90 and cesium–137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical error from replicate analyses experiments (*3*). The practical reporting level reflects additional analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurement equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical errors of precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium-89	1-5 pCi/liter for levels <50 pCi/liter; 5-10% for levels ≥ 50 pCi/liter
Strontium-90	1-2 pCi/liter for levels <20 pCi/liter; 4-10% for levels ≥ 20 pCi/liter
Iodine-131 Cesium-137 Barium-140	4-10 pCi/liter for levels <100 pCi/liter; 4-10% for levels ≥ 100 pCi/liter

For iodine-131, cesium-137, and barium-140 there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environment conditions is presented below. The function of the Council is to provide guidance to Federal agencies in the formulation of radiation standards.

Radiation Protection Guides (*8,9*)

The Radiation Protection Guide (RPG) has been defined by the Federal Radiation Council (FRC) as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable. An RPG provides radiation protection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risk to the general public that might result from exposures from routine uses of ionizing radiation and the benefits from the activities causing the exposure.

Table 1 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable. A more detailed discussion of these values was presented earlier (*3*).

In the absence of specific dietary data one can use milk as the indicator food item for routine surveillance. Assuming a 1-liter per day intake of milk, one can utilize the graded approach of daily intake on the basis of radionuclide content in milk samples collected to represent general population consumption. Under these assumptions, the radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Table 1. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Nuclide	Critical organ	RPG for individual in the general population (rad/a)	Guidance for suitable samples of exposed population group[a]				
			RPG (rad/a)	Corresponding continuous daily intake (pCi/day)	Range I (pCi/day)[b]	Range II (pCi/day)[b]	Range III (pCi/day)[b]
Strontium-89	Bone	[c]1.5	0.5	[d]2,000	0-200	200-2,000	2,000-20,000
	Bone marrow	[c] .5	.17				
Strontium-90	Bone	[c]1.5	.5	[d]200	0-20	20-200	200-2,000
	Bone marrow	[c] .5	.17				
Iodine-131	Thyroid	1.5	.5	100	0-10	10-100	100-1,000
Cesium-137[e]	Whole body	.5	.17	3,600	0-360	360-3,600	3,600-36,000

[a] Suitable samples which represent the limiting conditions for this guidance are: strontium-89, strontium-90—general population; iodine-131—children 1 year of age; cesium-137—infants.

[b] Based on an average intake of 1 liter of milk per day.

[c] A dose of 1.5 rad/a to the bone is estimated to result in a dose of 0.5 rad/a to the bone marrow.

[d] For strontium-89 and strontium-90, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third the respective RPG.

[e] The guides expressed here were not given in the FRC reports, but were calculated using appropriate FRC recommendations.

Protective Action Guides (*10,11*)

The Protective Action Guide (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the accidental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a one or two year period in a particular area would require special consideration. Protective actions are appropriate when the health benefits associated with the reduction in exposure to be acheived are sufficient to offset the undesirable features of the protective actions.

Table 2 presents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable. A more detailed discussion of these values was presented earlier (*3*). Also given in table 2 are milk concentrations for each of the radionuclides considered, in the absence of others, which if attained after an acute incident, would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentration from an idealized model for any acute deposition and the pasture-cow-milk-man pathway, as well as an estimate of the intake prior to reaching the maximum concentration. Therefore, these maximum concentrations are intended for use in estimating future

Table 2. Protective Action Guides—FRC recommendations and related information pertaining to environmental levels during an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Maximum concentration in milk for single nuclide that would result in PAG (pCi/liter)
Strontium-89 Strontium-90 Cesium-137	Bone marrow Bone marrow Whole body	10 in first yr: total dose not to exceed 15[a,b]	3 in first yr; total dose not to exceed 5[a,b]	[c]1,110,000 [c]51,000 [c]720,000
Iodine-131	Thyroid	30	10	[d]70,000

[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.

[b] Total dose from strontium-89 and cesium-137 is the same as dose in first year; total dose from strontium-90 is 5 times strontium-90 dose in first year for children approximately 1 year of age.

[c] These values represent concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.

[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration observed in milk from an acute contaminating event. A maximum of 84,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered. Children, 1 year of age, are assumed to be the critical segment of the population.

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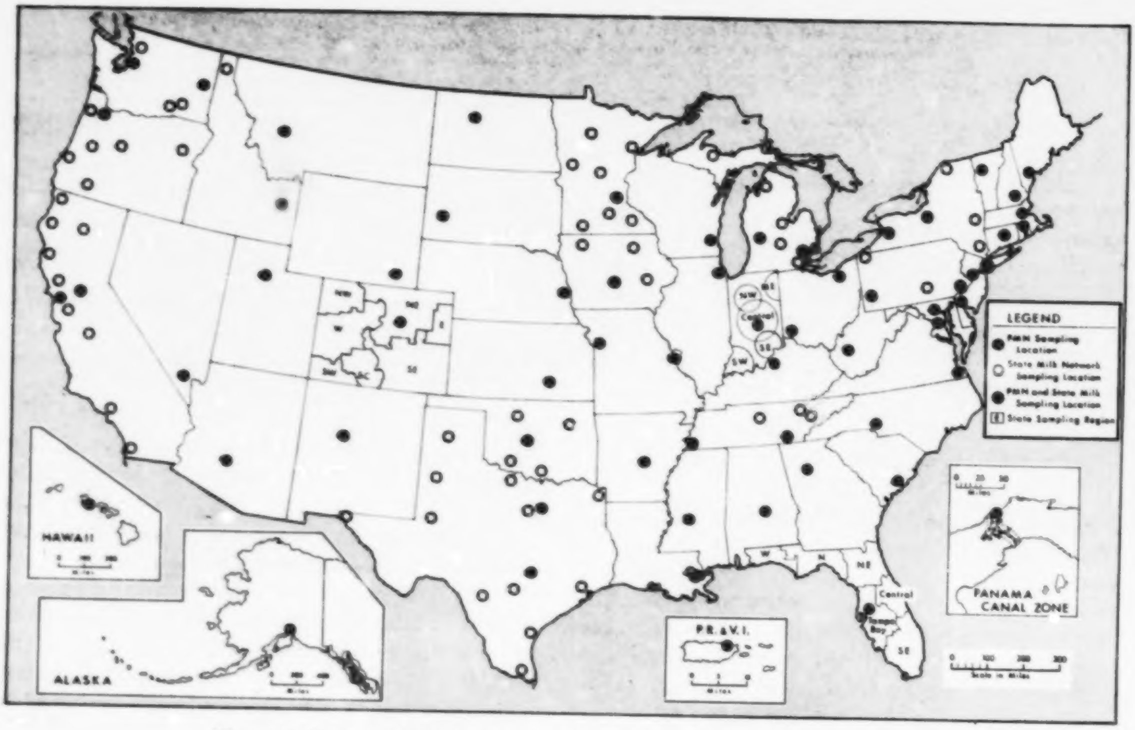

Figure 2. State and PMN milk sampling locations in the United States

intake on the basis of a few early samples rather than in retrospective manner.

Data reporting format

Table 3 presents the integrated results of the international, national and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports*. (The relationship between the PMN stations and State stations is shown in figure 2). The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 3, surveillance results are given for strontium-89, strontium-90, iodine-131, and cesium-137 for July 1969 and the 12-month period, August 1968-July 1969. Except where noted the monthly average represents a single sample for the sampling station. Barium-140 data has been omitted from table 3 since levels at the great majority of the stations for July 1969 were below the respective practical reporting levels.

Iodine-131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council (see

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Table 3. Concentrations of radionuclides in milk for July 1969 and 12-month period, August 1968 through July 1969

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)							
			Strontium-89		Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:										
Ala:	Montgomery[c]	P	4 (5)	0	6 (5)	7	0 (5)	0	13 (5)	11
Alaska:	Palmer[c]	P	0	0	8	6	0	0	0	11
Ariz:	Phoenix[c]	P	0	0	0	1	0 (5)	0	0 (5)	1
Ark:	Little Rock[c]	P	4	1	18	19	0 (4)	0	17 (4)	18
Calif:	Sacramento[c]	P	0	0	3	2	0 (3)	0	0 (3)	1
	San Francisco[c]	P	0	0	0	2	0 (5)	0	0 (5)	0
	Del Norte	P	11	7	22	20	0	0	0	20
	Fresno	P	0	0	0	0	0	0	0	3
	Humboldt	P	9	2	6	5	0	0	0	11
	Los Angeles	P	NA		NA	1	0	0	0	4
	Mendocino	P	NA		NA	3	NA	0	NA	3
	Sacramento	P	0		4	3	0	0	0	3
	San Diego	P	0		0	0	0	0	0	3
	Santa Clara	P	0		2	0	0	0	0	4
	Shasta	P	0		4	3	0	0	0	5
	Sonoma	P	0		4	3	0	0	0	3
Colo:	Denver[c]	P	12	1	4	5	0 (5)	0	6 (5)	3
	West	R	(d)		(d)		0	0 (5)	0	0 (5)
	Northeast	R	(d)		(d)		0	0 (6)	NS	0 (6)
	East	R	(d)		(d)		NS	0 (3)	NS	0 (3)
	Southeast	R	(d)		(d)		0	0 (3)	0	0
	South central	R	(d)		(d)		NS	0	NS	0 (9)
	Southwest	R	(d)		(d)		NS	0 (4)	NS	0 (2)
	Northwest	R	(d)		(d)		0	0 (2)	0	
Conn:	Hartford[c]	P	0	0	8	8	0 (4)	0	14 (4)	12
	Central	P	0	0	6	7	0 (3)	0	18 (3)	10
Del:	Wilmington[c]	P	0	0	10	9	0 (5)	0	7 (5)	7
D.C:	Washington[c]	P	2 (4)	1	7 (4)	8	0 (4)	0	8 (4)	4
Fla:	Tampa[c]	P	0 (5)	0	6 (5)	8	0 (5)	0	64 (5)	62
	West	R	(d)		15	11	0	1	30	24
	North	R	(d)		13	14	0	0	46	33
	Northeast	R	(d)		6	8	0	0	51	70
	Central	R	(d)		6	8	0	1	27	62
	Tampa Bay area	R	(d)		8	8	0	0	73	65
	Southeast	R	(d)		9	9	0	0	110	111
Ga:	Atlanta[c]	P	0 (5)	0	11 (5)	12	0 (3)	0	20 (5)	10
Hawaii:	Honolulu[c]	P	0 (5)	0	1 (5)	4	0 (5)	0	0 (5)	1
Idaho:	Idaho Falls[c]	P	6	1	5	5	0 (4)	0	8 (4)	7
Ill:	Chicago[c]	P	13	1	8	8	0 (4)	0	13 (4)	10
Ind:	Indianapolis[c]	P	0	0	8	8	0 (4)	0	8 (4)	6
	Northeast	P	5	0	22	12	0	0	20	9
	Southeast	P	5	0	18	9	0	0	10	12
	Central	P	10	1	22	10	0	0	10	11
	Southwest	P	10	1	20	9	0	0	10	12
	Northwest	P	10	1	20	10	0	0	20	14
Iowa:	Des Moines[c]	P	10	1	9	6	0 (5)	0	7 (5)	3
	Iowa City	P	NS							
	Des Moines	P	NS							
	Spencer	P	NS							
	[illegible]	P	NS							
Kan:	[illegible]	P	11	1	8	7	0 (4)	0	0 (4)	2
Ky:	[illegible]	P	10 (5)	2	9 (5)	10	0 (5)	0	0 (5)	6
La:	[illegible]	P	0 (5)	1	18 (5)	18	0 (5)	0	25 (5)	20
[illegible]	[illegible]	P	0	0	14	12	0 (4)	1	25 (4)	24
[illegible]	[illegible]	P	1 (5)	1	11 (5)	9	0 (5)	0	8 (5)	7
[illegible]	[illegible]	P	6	1	15	11	0 (4)	0	31 (4)	22
[illegible]	[illegible]	P	0	0	10	8	0 (4)	0	11 (4)	10
	[illegible]	P	0	0	11	10	0 (4)	0	16 (4)	14
	[illegible]	P	(d)		NS	4	NS	(e)	NS	10
	[illegible]	P	(d)		14	10	(e) (3)	(e)	22 (3)	15
	[illegible]	P	(d)		9	5	(e) (4)	(e)	10 (4)	4
	[illegible]	P	(d)		14	7	(e) (4)	(e)	18 (4)	10
	[illegible]	P	(d)		NS	5	(e) (2)	(e)	27 (2)	6
	[illegible]	P	(d)		12	9	(e) (2)	(e)	34 (2)	28
	[illegible]	P	(d)		9	3	(e) (2)	(e)	0 (2)	1
	South Haven	P	(d)		NS	7	NS	(e)	NS	8
Minn:	Minneapolis[c]	P	17	1	10	11	0 (5)	0	10 (5)	11
	Bemidji	P	(d)		21	17	0	0	32	23
	Mankato	P	(d)		10	7 (11)	0	0	12	0
	Rochester	P	(d)		11	9	0	0	0	0
	Duluth	P	(d)		22	20 (11)	0	0	41	27 (11)
	Worthington	P	(d)		8	7	0	0	0	0
	Minneapolis	P	(d)		13	12	0	0	0	12
	Fergus Falls	P	(d)		9	9	0	0	11	0
	Little Falls	P	(d)		12	10	0	0	16	16
Miss:	Jackson[c]	P	5 (3)	1	11 (3)	14	0 (3)	0	20 (3)	16
Mo:	Kansas City[c]	P	22	3	8	7	0 (4)	0	2 (4)	2
	St. Louis[c]	P	8	1	9	9	0 (5)	0	0 (5)	4
Mont:	Helena[c]	P	8	1	5	5	0 (5)	0	5 (5)	7
Nebr:	Omaha[c]	P	15	2	7	6	0 (4)	0	2 (4)	3
Nev:	Las Vegas[c]	P	0	0	0	1	0 (5)	0	0 (5)	1

See footnotes at end of table.

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Table 3. Concentrations of radionuclides in milk for July 1969 and 12-month period, August 1968 through July 1969—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)							
			Strontium-89		Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average	M9nthly average[b]	12-month average
N.H:	Manchester[c]	P	0	0	7	10	0 (5)	0	21 (5)	27
N.J:	Trenton[c]	P	0	0	9	9	0 (4)	0	9 (4)	8
N.Mex:	Albuquerque[c]	P	0	0	3	2	0 (4)	0	0 (4)	1
N.Y:	Buffalo[c]	P	0	0	10	7	0 (4)	0	5 (4)	9
	New York City[c]	P	0	0	11	10	0 (3)	0	15 (3)	13
	Syracuse[c]	P	0	0	9	8	0 (5)	0	6 (5)	8
	Albany	P	(d)		7 (4)	7	0 (4)	0	(e) (4)	(e)
	Buffalo	P	(d)		9	5 (7)	0	0 (7)	(e)	(e)
	Massena	P	(d)		13 (2)	11	0 (2)	0	22 (2)	(e)
	Newburg	P	(d)		16	11	0	0	(e)	(e)
	New York City	P	(d)		7 (3)	11	0 (3)	0	(e) (3)	(e)
	Syracuse	P	(d)		5 (2)	8	10 (2)	0	(e) (2)	(e)
N.C:	Charlotte[c]	P	4 (4)	1	13 (4)	15	0 (4)	0	10 (4)	12
N.Dak:	Minot[c]	P	22	3	9	11	0 (4)	0	20 (4)	13
Ohio:	Cincinnati[c]	P	0	0	9	8	0 (5)	0	2 (5)	3
	Cleveland[c]	P	0	0	11	9	0 (4)	0	8 (4)	7
Okla:	Oklahoma City[c]	P	6 (4)	1	7 (4)	9	0 (4)	0	14 (4)	9
	Oklahoma City	P	NS							
	Enid	P	NS							
	Tulsa	P	NS							
	Lawton	P	NS							
	Ardmore	P	NS							
Ore:	Portland[c]	P	9	2	5	7	0 (4)	0	11 (4)	9
	Baker	P	(d)		2	3 (6)	(e)		(e)	8
	Coos Bay	P	(d)		3	6 (6)	(e)		(e)	14
	Eugene	P	(d)		3	4 (6)	(e)		(e)	11
	Medford	P	(d)		2	2 (6)	(e)		(e)	14
	Portland composite	P	(d)		3	4 (6)	(e)		(e) (3)	4
	Portland local	P	(d)		5	5 (6)	(e)		16 (4)	6
	Redmond	P	(d)		0	1 (6)	(e)		(e)	5
	Tillamook	R	(d)		8	8 (5)	(e)		34	23
Pa:	Philadelphia[c]	P	NA	0	NA	9	0 (3)	0	3 (3)	5
	Pittsburgh[c]	P	0	0	13	11	0 (5)	0	14 (5)	9
	Dauphin	P	(d)		NS		NS		NS	
	Erie	P	(d)		13	11 (11)	0	0	31	21
	Philadelphia	P	(d)		NS		NS		NS	
	Pittsburgh	P	(d)		13	11	11	0	20	14
R.I:	Providence[c]	P	0	0	11	9	0 (5)	0	21 (5)	18
S.C:	Charleston[c]	P	0 (5)	0	11 (5)	12	0 (5)	0	27 (5)	24
S.Dak:	Rapid City[c]	P	27	3	13	8	0 (4)	0	13 (4)	7
Tenn:	Chattanooga[c]	P	4 (4)	2	11 (4)	12	0 (4)	0	15 (4)	13
	Memphis[c]	P	1 (5)	1	9 (5)	10	0 (5)	0	7 (5)	5
	Chattanooga	P	7	3	26	13	0 (4)	0	13 (4)	15
	Clinton	P	5	2	24	15	7 (2)	0	11 (2)	16
	Knoxville	P	0	1	12	10	0	1	0	8
	Nashville	P	9	2	6	9	0 (2)	0	0 (2)	5
Tex:	Austin[c]	P	3 (3)	1	1 (3)	2	0 (3)	0	6 (3)	3
	Dallas[c]	P	2 (4)	1	7 (4)	7	0 (4)	0	6 (4)	6
	Amarillo	R	(d)		NS	4	NS	0	NS	0
	Corpus Christi	R	(d)		NS	4	NS	0	NS	0
	El Paso	R	(d)		NS	3	NS	0	NS	0
	Fort Worth	R	(d)		4	6	0	0	0	10
	Harlingen	R	(d)		NS	4	NS	0	NS	0
	Houston	R	(d)		6	7	0	0	15	19
	Lubbock	R	(d)		NS	4	NS	0	NS	3
	Midland	R	(d)		2	2	0	0	0	0
	San Antonio	R	(d)		NS	3	NS	0	NS	0
	Texarkana	R	(d)		NS	12	NS	0	NS	16
	Uvalde	R	(d)		NS	1	NS	0	NS	0
	Wichita Falls	R	(d)		NS	6	NS	0	NS	5
Utah:	Salt Lake City[c]	P	0	0	3	5	0 (5)	0	5 (5)	8
Vt:	Burlington[c]	P	0	0	9	9	0 (5)	0	14 (5)	12
Va:	Norfolk[c]	P	0 (4)	0	10 (4)	11	0 (4)	0	6 (4)	7
Wash:	Seattle[c]	P	0	1	0	8	0 (5)	0	19 (5)	17
	Spokane[c]	P	0	1	8	6	0 (5)	0	4 (5)	6
	Benton County	R	(d)		0	1	0	0	0	6
	Franklin County	R	(d)		NS	1	NS	0	NS	0
	Sandpoint, Idaho	R	(d)		15	10	0	0	41	26
	Skagit County	R	(d)		7	7	0	0	17	11
W.Va:	Charleston[c]	P	2 (5)	1	10 (5)	10	0 (5)	0	6 (5)	8
Wisc:	Milwaukee[c]	P	0	0	8	7	0 (4)	0	8 (4)	12
Wyo:	Laramie[c]	P	8	1	7	5	0 (5)	0	11 (5)	10
CANADA:										
Alberta:	Calgary	P	(d)		10	8	(d)		18	16
	Edmonton	P	(d)		8	7	(d)		19	17
British Columbia:	Vancouver	P	(d)		11	13	(d)		31	40

See footnotes at end of table.

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Table 3. Concentrations of radionuclides in milk for July 1969 and 12-month period, August 1968 through July 1969—Continued

Sampling location	Type of sample[a]	Radionuclide concentration (pCi/liter)							
		Strontium-89		Strontium-90		Iodine-131		Cesium-137	
		Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA—Continued									
Manitoba:									
Winnipeg	P	([d])		11	8	([d])		33	25
New Brunswick:									
Fredericton	P	([d])		18	14	([d])		23	20
Newfoundland:									
St. Johns	P	([d])		36	19	([d])		60	38
Nova Scotia:									
Halifax	P	([d])		12	11	([d])		44	21
Ontario: Ft. William	P	([d])		19	16	([d])		44	32
Ottawa	P	([d])		9	9	([d])		22	17
Saulte Ste. Marie	P	([d])		17	16	([d])		31	33
Toronto	P	([d])		6	5	([d])		17	13
Windsor	P			7	6	([d])		6	13
Quebec: Montreal	P	([d])		11	9	([d])		19	19
Quebec	P	([d])		13	12	([d])		28	27
Saskatchewan:									
Regina	P	([d])		8	7	([d])		13	16
Saskatoon	P	([d])		7	9	([d])			16
CENTRAL AND SOUTH AMERICA:									
Columbia:									
Bogota									
Chile: Santiago	P	0	0	0	0	0	0	0	
Ecuador:									
Guayaquil	P	0	0	0	0	0	0	0	
Jamaica: Kingston	P	2	10	2	5	0	0	50	90
Venezuela:									
Caracas	P	3	0	3	1	0	0	0	0
Canal Zone:									
Cristobal[c]	P	0	4	1	2	0 (4)	1	12 (4)	14
Puerto Rico:									
San Juan[c]	P	2	0	3	1	0 (4)	0	14 (4)	7
PMN Network average[f]		4	1	8	8	0	0	10	10

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] PHS Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones giving in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine-131:	Colorado-25 pCi/liter	Cesium-137:	Colorado-25 pCi/liter
	Michigan-14 pCi/liter		New York-20 pCi/liter
	Oregon-15 pCi/liter		Oregon-15 pCi/liter

[f] This entry gives the average radionuclide concentrations for the PHS Pasteurized Milk Network stations denoted by footnote [c].

NA, no analysis.

NS, no sample collected.

table 1), levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting levels for iodine-131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium-90 monthly averages ranged from 0 to 26 pCi/liter in the United States for the month of July 1969 and the highest 12-month average was 20 pCi/liter (Del Norte, Calif. and Duluth, Minn.), representing 10 percent of the Federal Radiation Council radiation protection guide (table 1). St. Johns, Newfoundland reported an average of 36 pCi/liter for strontium-90. Cesium-137 monthly averages ranged from 0 to 110 pCi/liter in the United States for the month of July 1969 and the highest 12-month average was 111 pCi/liter (southeast Florida), representing 3 percent of the value presented in this report using the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*12*) and Jamaica. Iodine-131 monthly averages were all below the practical reporting level.

Acknowledgment

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Colorado State Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Division of Radiological Health
Bureau of Preventable Diseases
Florida State Board of Health

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiological Health Service
Division of Occupational Health
Michigan Department of Health

Radiation Protection Division
Canadian Department of National
Health and Welfare

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Health
Division of Environmental Health Services
New York State Department of Health

Division of Occupational and Radiological
Health
Environmental Health Services
Oklahoma State Department of Health

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

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(*12*) PORTER, C. R., C. P. PHILLIPS, M. W. CARTER, and B. KAHN. The Cause of Relatively High Cesium-137 Concentrations in Tampa, Fla. Milk. Radioecological Concentration Processes, Proceedings of an International Symposium held in Stockholm, April 25–29, 1966. Pergamon Press, New York, N.Y. (1966) pp. 95–101.

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows.

Program	Period reported	Issue
California Diet Study	November 1967–September 1968	May 1969
Connecticut Diet Study	January–June 1968	November 1968
Tri-City Diet, *HASL*	January–June 1968	April 1969
Institutional Diet	Annual summary 1968 and January—March 1969	October 1969

Carbon-14, Tritium, and Plutonium-239 in Milk and Total Diet July 1965 to December 1968

Bureau of Radiological Health
U.S. Public Health Service

The Bureau of Radiological Health initiated a program in July 1965 to determine the levels of carbon-14, tritium, and plutonium-239 in the total diet and milk in the United States. Initially, monthly samples from each of the PHS Institutional Total Diet Sampling Network (ITDSN), and Pasteurized Milk Network (PMN) stations were composited and analyzed according to six selected regions: Northeast, South, Delta, Central, Southwest, and Northwest. Figure 1 shows the ITDSN and PMN sampling stations in each of the designated regions.

In January 1966, it was decided to obtain and analyze samples from selected stations in each of the previously mentioned regions, and to include Alaska and Hawaii in the program. Nine geographically distributed sampling stations were selected: Boston, Mass; Chicago, Ill; Charleston, S.C; New Orleans, La; Idaho Falls, Idaho; Portland, Ore; Los Angeles, Calif; Palmer, Alaska; and Honolulu, Hawaii. Los Angeles, Calif., is not a PMN station, but a special milk sample is collected for purposes of comparison with the routine ITDSN sample.

A 1-liter milk sample and a 2-kilogram food sample are sent to the PHS Northeastern Radiological Health Laboratory for analysis. The milk samples analyzed represent a composite of the samples collected during the last 2 weeks of the month, and the total diet samples analyzed represent the samples collected for that month.

Analytical procedures

Tritium analyses are performed monthly, carbon-14 analyses are done semiannually, and plutonium-239 analyses are performed on 6-month composite samples. Carbon-14 content is determined by oxidation of the milk or food sample and collection and purification of the evolved carbon dioxide; the carbon dioxide is then converted to methane and counted in a gas-proportional counter (*1*). The aqueous portion of the sample is collected and retained for tritium determination when the carbon-14 analysis is required; otherwise, the sample is collected by distillation. In some cases, the sample is electrolytically enriched (*1*) prior to liquid scintillation counting. The procedure for plutonium-239 analysis has been reported previously (*2*).

Table 1. Plutonium-239 in milk and total diet, 1966–1968

Location		Collection period	Concentration (fCi/kg)	
			Milk	Total diet
Mass:	Boston	1/66–6/66	ND	ND
		7/66–12/66	ND	ND
		1/67–6/67	ND	ND
		7/67–[a] 12/67		6.5
		1/68–6/68		ND
		7/68–12/68		ND
S.C:	Charleston	1/66–6/66	ND	4.5
		7/66–12/66	ND	ND
		1/67–6/67	ND	ND
		7/67–[a] 12/67		ND
		1/68–6/68		ND
		7/68–12/68		ND
La:	New Orleans	1/66–6/66	ND	4.6
		7/66–12/66	ND	ND
		1/67–6/67	ND	ND
		7/67–[a] 12/67		ND
		1/68–6/68		ND
		7/68–12/68		ND
Ill:	Chicago	1/66–6/66	ND	4.5
		7/66–12/66	ND	ND
		1/67–6/67	ND	4.8
		7/67–[a] 12/67		ND
		1/68–6/68		ND
		7/68–12/68		NS
Idaho:	Idaho Falls	1/66–6/66	ND	7.9
		7/66–12/66	ND	ND
		1/67–6/67	4.3	ND
		7/67–[a] 12/67		ND
		1/68–6/68		ND
		7/68–12/68		Lost
Ore:	Portland	1/66–6/66	ND	4.4
		7/66–12/66	ND	NS
		1/67–6/67	ND	ND
		7/67–[a] 12/67		ND
		1/68–6/68		ND
		7/68–12/68		ND
Alaska:	Palmer	7/66–12/66	ND	ND
		1/67–6/67	ND	ND
		7/67–[a] 12/67		7.9
		1/68–6/68		ND
		7/68–12/68		ND
Hawaii:	Honolulu	6/66	ND	ND
		7/66–12/66	ND	ND
		1/67–6/67	ND	ND
		7/67–[a] 12/67		ND
		1/68–6/68		ND
		7/68–12/68		ND
Calif.	Los Angeles	1/66–6/66	NS	ND
		7/66–12/66	NS	NS
		1/67–6/67	NS	ND
		7/67–[a] 12/67		2.9
		1/68–6/68		ND
		7/68–12/68		ND

[a] Discontinued plutonium-239 analysis on milk as of July 1967.
ND, nondetectable, less than 2-sigma counting error.
NS, no sample.

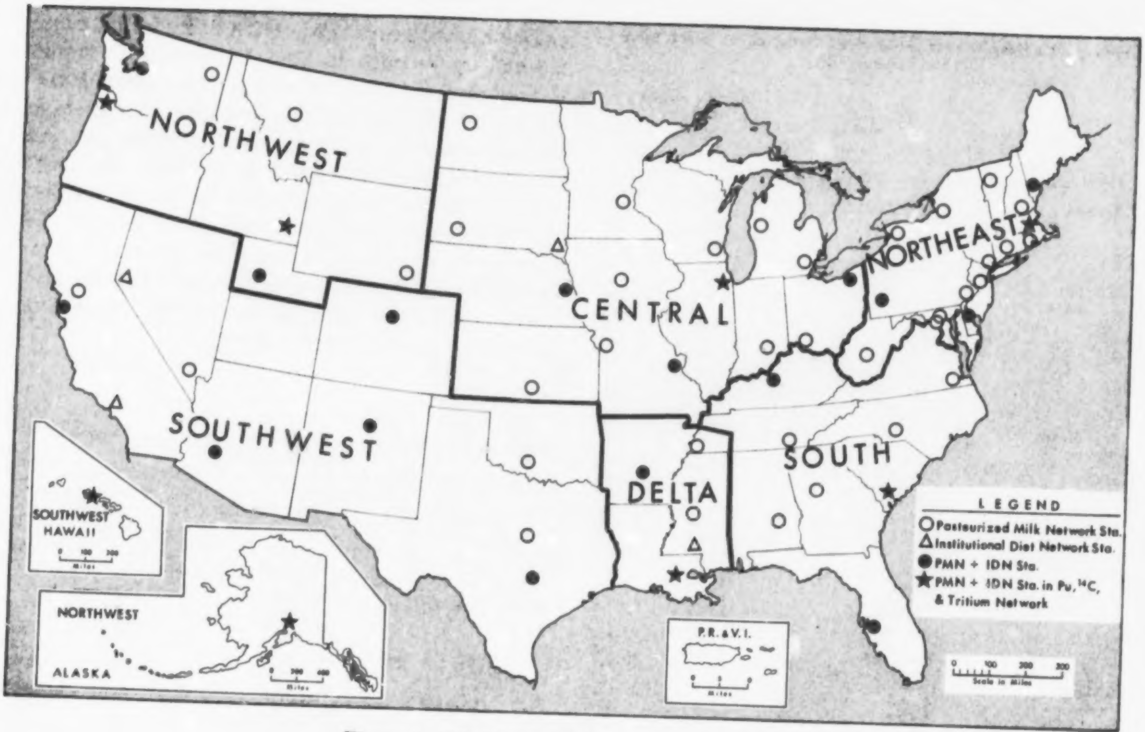
NORTHWEST
SOUTHWEST
CENTRAL
NORTHEAST
SOUTH
DELTA
SOUTHWEST HAWAII
NORTHWEST ALASKA
P.R. & V.I.
LEGEND
○ Pasteurized Milk Network Sta.
△ Institutional Diet Network Sta.
● PMN + IDN Sta.
★ PMN + IDN Sta. in Pu, 14C, & Tritium Network
Scale in Miles

Figure 1. ITDSN and PMN sampling stations

Results and discussion

Plutonium-239 results for July–December 1965 have been reported previously (2). The data for plutonium-239 in milk for January 1966–June 1967 are shown in table 1. The results indicated that plutonium-239 was not present in detectable quantities, and, as a result, the analysis of milk for plutonium-239 was discontinued in June 1967.

The data for plutonium-239 in total diet samples for January 1966–December 1968 are also given in table 1. For January–June 1966, plutonium-239 was generally present in relatively low but detectable amounts in food samples with a maximum concentration for this period of 7.9 fCi/kg. Since June 1966, concentrations of plutonium-239 in total diet samples have been generally below detectable limits. The minimum detectable radioactivity for plutonium-239 is 15 fCi in any given sample. ND has been used in table 1 to represent samples with a radioactivity less than or equivalent to this value.

The data obtained from the selected regions during the period, July–December 1965, for carbon-14 in total diet and milk are given in table 2. The mean carbon-14 concentration in food for the 6-month period ranged from 1,010 to 1,220 pCi/kg. The mean for all stations for this period was 1,120 pCi/kg. For milk during this period, the mean carbon-14 concentration ranged from 550 to 620 pCi/kg. The mean for all stations was 570 pCi/kg.

From January 1966 through December 1968, analysis for carbon-14 was done on a semiannual basis (in April and October) for samples from each of the nine selected stations. These data are given in table 3. The mean for all stations for each half year for total diet increased from 1,130 pCi/kg in April 1966 to 1,300 pCi/kg in April 1967, but since then has steadily decreased to 1,030 pCi/kg in October 1968. For milk, the values appear to be about the same as in 1965, with the suggestion of a spring rise for the April samples.

Table 2. Carbon-14 in milk and total diet, July 1965–December 1965

Region	Date collected (1965)	Concentration (pCi/kg)	
		Total diet	Milk
Northeast	July	1,260	640
	August	1,100	560
	September	1,200	460
	October	1,010	600
	November	1,110	560
	December	1,190	760
Mean		1,150	600
South	July	1,100	520
	August	1,210	470
	September	1,210	590
	October	1,360	550
	November	1,090	540
	December	1,330	670
Mean		1,220	560
Delta	July	1,010	490
	August	900	660
	September	1,120	620
	October	1,010	670
	November	1,150	610
	December	1,150	660
Mean		1,060	620
Southwest	July	1,040	520
	August	1,180	NS
	September	1,380	NS
	October	920	590
	November	990	580
	December	1,130	560
Mean		1,130	560
Northwest	July	970	470
	August	1,050	NS
	September	980	NS
	October	940	520
	November	950	570
	December	1,180	640
Mean		1,010	550
Central	July	1,090	600
	August	1,080	NS
	September	1,210	590
	October	1,180	550
	November	1,140	450
	December	1,170	530
Mean		1,140	550

NS, no sample.

The results for tritium in milk and total diet for the period, July–December 1965, are given in table 4. Detectable values ranged from 1.5 to 4.9 nCi/kg for food samples and from 1.7 to 8.9 nCi/kg for milk samples, since none of these samples were enriched.

The results for tritium in milk and total diet for 1966, 1967, and 1968, are given in tables 5, 6, and 7, respectively. For 1966, the detectable values ranged from 0.4 to 9.9 nCi/kg for food samples and from 0.8 to 5.9 nCi/kg for milk samples; the average for the electrolytically enriched samples was 1.2 nCi/kg for food and 1.4 nCi/kg for milk. In 1967, the detectable values ranged from 0.4 to 2.7 nCi/kg for food samples and from 0.3 to 3.6 pCi/kg for milk samples; the average for the electrolytically enriched samples was 0.7 nCi/kg for food and 0.6 nCi/kg for milk. In 1968, the detectable values ranged from 0.4 to 2.2 nCi/kg for food samples and 0.5 to 1.7 nCi/kg for milk samples; the average for the electrolytically enriched samples was 0.6 nCi/kg for diet and 0.5 nCi/kg for milk. For averaging purposes, zero was used for those samples with concentrations below detectable limits. The number of samples with less than detectable concentrations increased markedly between 1966 and 1968, and this is reflected in steadily decreasing average values during this period.

Table 3. Carbon-14 in milk and total diet, April 1966–October 1968

Location		Date collected	Concentration (pCi/kg)	
			Milk	Total diet
Mass:	Boston	April 1966	670	1,050
		Oct. 1966	NS	1,280
		April 1967	1,040	1,140
		Oct. 1967	760	1,140
		April 1968	740	1,120
		Oct. 1968	550	1,080
S.C:	Charleston	April 1966	640	830
		Oct. 1966	690	770
		April 1967	670	1,400
		Oct. 1967	550	1,450
		April 1968	460	1,160
		Oct. 1968	630	1,020
La:	New Orleans	April 1966	540	1,170
		Oct. 1966	350	1,250
		April 1967	760	1,150
		Oct. 1967	550	1,240
		April 1968	700	1,180
		Oct. 1968	630	1,140
Ill:	Chicago	April 1966	610	1,510
		Oct. 1966	640	1,220
		April 1967	620	1,360
		Oct. 1967	610	1,260
		April 1968	390	1,020
		Oct. 1968	510	NS
Idaho:	Idaho Falls	April 1966	710	1,320
		Oct. 1966	550	1,470
		April 1967	670	1,250
		Oct. 1967	410	1,180
		April 1968	470	1,210
		Oct. 1968	440	1,170
Ore:	Portland	April 1966	490	1,030
		Oct. 1966	510	1,450
		April 1967	480	1,280
		Oct. 1967	650	1,240
		April 1968	500	1,280
		Oct. 1968	500	1,110
Calif:	Los Angeles	April 1966	NS	800
		Oct. 1966	NS	1,140
		April 1967	NS	1,450
		Oct. 1967	430	1,000
		April 1968	590	1,180
		Oct. 1968	450	770
Alaska:	Palmer	Oct. 1966	590	NS
		April 1967	650	1,400
		Oct. 1967	390	920
		April 1968	480	1,020
		Oct. 1968	360	980
Hawaii:	Honolulu	Oct. 1966	NS	1,010
		April 1967	520	1,170
		Oct. 1967	790	1,130
		April 1968	640	1,270
		Oct. 1968	410	970

Table 4. Tritium content of total diet and milk July–December 1965

Region	Date collected (1965)	Concentration (nCi/kg)	
		Total diet	Milk
Northeast	July	4.2	ND
	August	3.7	ND
	September	4.4	ND
	October	ND	3.0
	November	ND	2.2
	December	ND	ND
South	July	ND	ND
	August	1.7	ND
	September	ND	ND
	October	1.7	3.4
	November	2.1	1.7
	December	4.9	ND
Delta	July	2.9	1.9
	August	3.8	ND
	September	3.1	ND
	October	ND	ND
	November	3.3	ND
	December	2.2	ND
Southwest	July	ND	ND
	August	ND	NS
	September	ND	NS
	October	ND	ND
	November	ND	ND
	December	2.8	2.2
Northwest	July	1.9	8.9
	August	ND	NS
	September	1.7	NS
	October	ND	ND
	November	ND	2.9
	December	ND	5.7
Central	July	3.4	ND
	August	2.3	NS
	September	1.5	ND
	October	ND	5.7
	November	2.1	2.0
	December	NS	ND

ND, nondetectable, less than 2σ counting error.
NS, no sample.

Table 5. Tritium content of total diet and milk, 1966

Location		Date collected (1966)	Concentration (nCi/kg)	
			Total diet	Milk
Calif:	Los Angeles	January	ND	NS
		February	4.9	NS
		March	ND	NS
		April	ND	NS
		May	3.1	NS
		June	ND	NS
		July	ND	NS
		August	NS	NS
		September	NS	NS
		October	3.0	NS
		November	ND	NS
		December	ND	NS
Ore:	Portland	January	7.3	ND
		February	ND	3.7
		March	ND	ND
		April	ND	4.6
		May	[a]1.7	NS
		June	2.9	ND
		July	3.5	ND
		August	ND	ND
		September	3.7	ND
		October	ND	NS
		November	ND	ND
		December	ND	ND

Table 5. Tritium content of total diet and milk, 1966—continued

Location		Data collected (1966)	Concentration (nCi/kg)	
			Total diet	Milk
Idaho:	Idaho Falls	January	[a]0.8	[a]1.9
		February	ND	ND
		March	ND	ND
		April	[a].4	3.3
		May	5.7	ND
		June	ND	3.5
		July	ND	ND
		August	3.4	ND
		September	[a]1.1	[a]1.6
		October	[a]1.2	6.7
		November	ND	ND
		December	ND	3.0
La:	New Orleans	January	4.6	2.7
		February	8.4	ND
		March	ND	ND
		April	ND	ND
		May	3.6	3.2
		June	9.9	NS
		July	ND	ND
		August	[a]1.4	[a].9
		September	ND	ND
		October	ND	ND
		November	ND	ND
		December	ND	ND
Ill:	Chicago	January	NS	ND
		February	ND	ND
		March	[a].8	[a].8
		April	[a]1.0	2.8
		May	4.4	4.2
		June	ND	ND
		July	2.8	ND
		August	ND	ND
		September	ND	ND
		October	ND	ND
		November	ND	ND
		December	NS	ND
S.C:	Charleston	January	ND	2.8
		February	ND	2.8
		March	2.8	3.0
		April	[a].8	[a]4.8
		May	ND	ND
		June	ND	ND
		July	2.0	1.9
		August	ND	3.0
		September	ND	ND
		October	[a]1.7	[a]1.3
		November	NS	5.9
		December	ND	ND
Mass:	Boston	January	NS	[a]1.5
		February	ND	[a]1.5
		March	6.8	ND
		April	[a].8	[a].8
		May	ND	2.4
		June	ND	2.4
		July	ND	ND
		August	NS	ND
		September	ND	ND
		October	ND	ND
		November	[a]1.6	[a]1.2
		December	ND	3.4
Hawaii:	Honolulu	June	[a]ND	[a]ND
		July	ND	ND
		August	ND	ND
		September	ND	NS
		October	3.6	ND
		November	ND	ND
		December	ND	ND
Alaska:	Palmer	July	[a]2.8	[a]1.0
		August	ND	ND
		September	ND	ND
		October	2.9	ND
		November	ND	ND
		December	ND	ND

[a] Electrolytically enriched.
ND, nondetectable, less than 2σ counting error.
NS, no sample.

For comparison purposes, Shleien determined dose commitments to adult individuals in the Northeastern part of the United States due to tritium and carbon-14 in the total diet (*3*). Using the data in this report, he found that the whole body dose is 0.4 mrem in 50 years for tritium and the gonadal dose is 1.1 mrem in 50 years for carbon-14. These doses can be compared to a natural radioactivity dose of approximately 5 rem in 50 years.

Table 6. Tritium content of total diet and milk, 1967

Location		Date collected (1967)	Concentration (nCi/kg)	
			Total diet	Milk
Calif:	Los Angeles	January	ND	NS
		February	ND	NS
		March	ND	NS
		April	ND	NS
		May	ND	NS
		June	ND	NS
		July	ND	NS
		August	ND	NS
		September	[a] .7	[a] .3
		October	ND	ND
		November	ND	ND
		December	ND	ND
Ore:	Portland	January	[a] .5	[a] .6
		February	ND	2.0
		March	ND	ND
		April	ND	ND
		May	ND	ND
		June	ND	ND
		July	[a] .4	[a] .3
		August	ND	ND
		September	ND	ND
		October	1.5	2.0
		November	ND	ND
		December	ND	ND
Idaho:	Idaho Falls	January	ND	ND
		February	2.5	ND
		March	ND	ND
		April	[a] 1.0	3.6
		May	[a] 1.0	[a] 1.0
		June	ND	ND
		July	ND	2.3
		August	ND	ND
		September	2.7	3.1
		October	1.2	1.3
		November	ND	1.9
		December	1.5	1.5
La:	New Orleans	January	ND	ND
		February	ND	ND
		March	[a] .6	[a] .2
		April	ND	ND
		May	ND	ND
		June	ND	ND
		July	NS	ND
		August	ND	ND
		September	ND	ND
		October	ND	ND
		November	ND	ND
		December	[a] .5	[a] .3
Ill:	Chicago	January	2.5	ND
		February	ND	ND
		March	ND	ND
		April	[a] .5	ND
		May	ND	ND
		June	ND	ND
		July	1.8	ND
		August	[a] .6	[a] .9
		September	ND	ND
		October	ND	ND
		November	ND	ND
		December	ND	1.4
S.C:	Charleston	January	ND	ND
		February	ND	ND
		March	ND	1.6
		April	ND	ND
		May	ND	ND
		June	ND	ND
		July	ND	2.1
		August	NS	ND
		September	2.3	2.2
		October	1.7	ND
		November	ND	ND
		December	1.3	1.9
Mass:	Boston	January	1.8	ND
		February	ND	ND
		March	ND	ND
		April	ND	[a] 1.2
		May	ND	ND
		June	[a] 1.0	[a] .9
		July	ND	ND
		August	NS	ND
		September	1.9	ND
		October	ND	ND
		November	ND	ND
		December	ND	1.5
Hawaii:	Honolulu	January	ND	ND
		February	1.8	ND
		March	ND	ND
		April	[a] .5	[a] .2
		May	ND	ND
		June	ND	ND
		July	ND	NS
		August	ND	ND
		September	ND	NS
		October	ND	ND
		November	[a] .2	[a] ND
		December	ND	ND
Alaska:	Palmer	January	ND	ND
		February	[a] 1.4	[a] 1.0
		March	ND	ND
		April	ND	ND
		May	ND	ND
		June	ND	NS
		July	2.4	ND
		August	2.0	ND
		September	2.4	ND
		October	[a] 1.1	[a] 1.0
		November	2.3	ND
		December	1.2	3.1

[a] Electrolytically enriched.
ND, nondetectable, less than 2σ counting error.
NS, no sample.

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Table 7. Tritium content of total diet and milk, 1968

Location	Date collected (1968)	Concentration (nCi/kg)	
		Total diet	Milk
Calif: Los Angeles	January	ND	ND
	February	1.1	1.6
	March	ND	NS
	April	ND	.8
	May	1.4	ND
	June	[a] .9	[a] ND
	July	1.0	NS
	August	2.1	ND
	September	ND	ND
	October	1.4	1.1
	November	.8	ND
	December	ND	1.6
Ore: Portland	January	1.5	ND
	February	ND	ND
	March	ND	ND
	April	[a] 1.4	[a] .4
	May	1.4	ND
	June	ND	ND
	July	ND	ND
	August	ND	ND
	September	ND	ND
	October	2.2	ND
	November	ND	ND
	December	ND	ND
Idaho: Idaho Falls	January	1.3	ND
	February	ND	1.4
	March	[a] .6	[a] 1.1
	April	1.2	1.6
	May	1.5	1.0
	June	ND	.9
	July	ND	1.7
	August	1.2	ND
	September	ND	ND
	October	ND	ND
	November	ND	ND
	December	[a] .8	[a] 1.0
La: New Orleans	January	1.2	ND
	February	ND	ND
	March	ND	ND
	April	ND	ND
	May	1.4	ND
	June	NS	ND
	July	ND	ND
	August	.7	ND
	September	[a] ND	[a] ND
	October	ND	ND
	November	.8	ND
	December	ND	ND
Ill: Chicago	January	ND	ND
	February	ND	ND
	March	ND	ND
	April	ND	ND
	May	[a] ND	[a] .5
	June	NS	1.6
	July	.8	ND
	August	NS	ND
	September	NS	.9
	October	NS	ND
	November	NS	ND
	December	NS	ND
S.C: Charleston	January	[a] 0.6	[a] 1.2
	February	ND	1.5
	March	1.4	ND
	April	.9	1.0
	May	ND	ND
	June	ND	ND
	July	1.0	ND
	August	.9	1.1
	September	ND	ND
	October	[a] .4	[a] ND
	November	ND	ND
	December	ND	ND
Mass: Boston	January	1.4	1.4
	February	[a] .8	[a] .8
	March	1.6	ND
	April	1.3	1.0
	May	.9	ND
	June	1.8	1.6
	July	1.3	.8
	August	.9	1.2
	September	.8	1.1
	October	ND	ND
	November	[a] ND	[a] ND
	December	ND	ND
Hawaii: Honolulu	January	1.3	ND
	February	ND	ND
	March	1.0	ND
	April	.9	ND
	May	ND	ND
	June	ND	ND
	July	ND	ND
	August	[a] ND	[a] ND
	September	ND	ND
	October	ND	ND
	November	1.2	ND
	December	ND	ND
Alaska: Palmer	January	ND	ND
	February	ND	ND
	March	1.0	ND
	April	.9	ND
	May	ND	ND
	June	ND	ND
	July	[a] 1.1	[a] .6
	August	ND	ND
	September	ND	ND
	October	1.1	.9
	November	1.3	.8
	December	ND	1.7

[a] Electrolytically enriched.
ND, nondetectable, less than 2σ counting error.
NS, no sample.

REFERENCES

(*1*) DROBINSKI, J. C., Jr., D. P. LAGATTA, A S. GOLDIN, and J. G. TERRILL. Analyses of environmental samples for carbon-14 and tritium. Health Physics 11:385-395 (1965).

(*2*) KAUFFMAN, P. E. and P. J. MAGNO. Plutonium-239 in total diet and milk. Radiol Health Data Rep 8:191-194 (April 1967).

(*3*) SHLEIEN, B. An evaluation of internal radiation exposure based on dose commitments from radionuclides in milk, food, and air. To be published.

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

Water sampling program	Period reported	Issue
Colorado River Basin	1967	December 1968
Drinking Water Analysis Program	1961–1966	August 1968
Florida	1967	February 1969
Kansas	July–December 1967	November 1968
New York	July–December 1968	September 1969
North Carolina	January–December 1967	May 1969
Washington	July 1967–June 1968	June 1969

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

REFERENCES

(*1*) U. S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies, Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Gross Radioactivity in Surface Waters of the United States April 1969

Division of Pollution Surveillance
Federal Water Pollution Control Administration
Department of the Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Water Pollution Surveillance System currently operated by the Federal Water Pollution Control Administration. Table 1 presents the current preliminary results of the alpha and beta radioanalyses. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended plus dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the November 1968 issue of *Radiological Health Data and Reports.*

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (*1–6*). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data for comment. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. A discussion of gross radio-

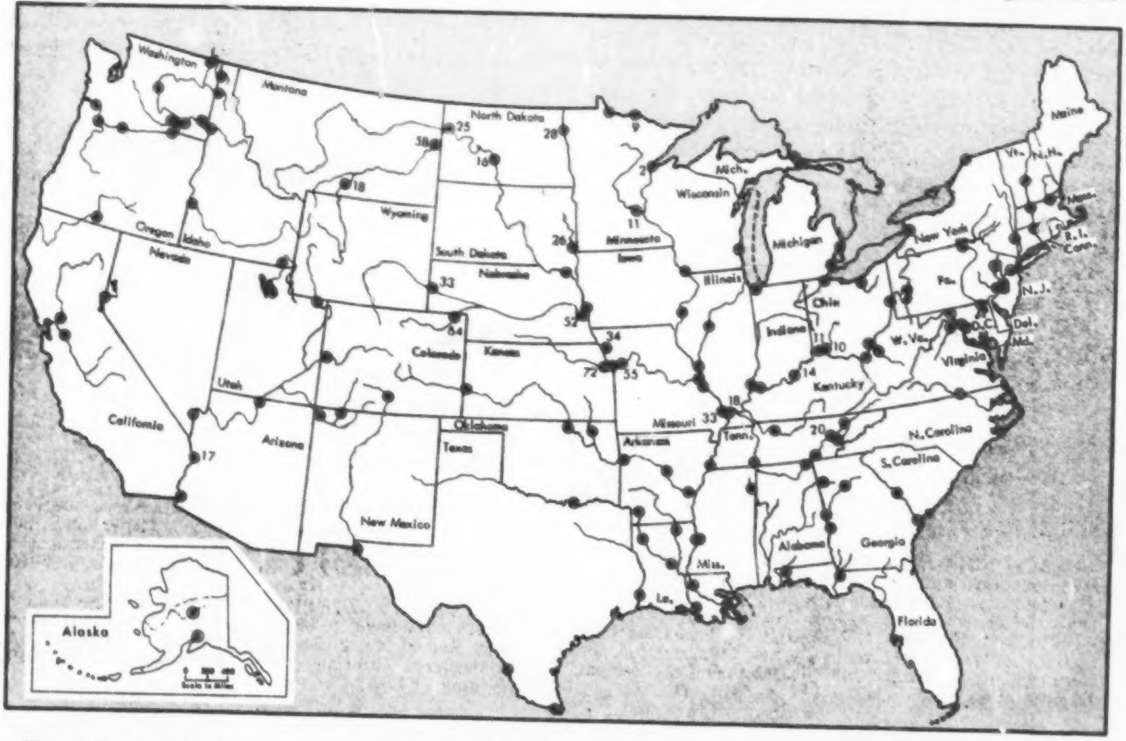
Washington
Montana
North Dakota
Oregon
Idaho
Nevada
Wyoming
South Dakota
Nebraska
Minnesota
Wisconsin
Mich.
Michigan
Iowa
Illinois
Indiana
Ohio
New York
Pa.
Maine
Vt.
N.H.
Mass.
R.I.
Conn.
N.J.
Del.
Md.
D.C.
W. Va.
Virginia
Kentucky
Tenn.
N. Carolina
S. Carolina
Georgia
Alabama
Miss.
La.
Florida
Arkansas
Missouri
Kansas
Oklahoma
Texas
New Mexico
Colorado
Utah
Arizona
California
Alaska
25
28
38
16
9
2
18
11
26
33
52
54
34
72
35
11
10
14
18
33
20
17
0
200
400
Scale in Miles

Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, April 1969

Table 1. Radioactivity in raw surface waters, April 1969

Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Big Horn River:						
Hardin, Mont	0	3	3	4	14	18
Big Sioux River:						
Sioux Falls, S. Dak	1	2	3	6	20	26
Clinch River:						
Kingston, Tenn[a]	0	<1	<1	1	19	20
Colorado River:						
Parker Dam, Calif–Ariz	0	3	3	2	15	17
Great Lakes:						
Duluth, Minn	0	0	0	0	2	2
Kansas River:						
DeSoto, Kans	12	0	12	59	13	72
Little Miami River:						
Cincinnati, Ohio	1	0	1	4	6	10
Mississippi River:						
St. Paul, Minn	0	2	2	3	8	11
Cape Girardeau, Mo	6	1	7	21	12	33
Missouri River:						
Williston, N. Dak	2	3	5	8	17	25
Bismark, N. Dak	0	4	4	3	13	16
St. Joseph, Mo	6	3	9	23	11	34
Missouri City, Mo	7	1	8	42	13	55
North Platte River:						
Henry, Nebr	<1	18	18	5	28	33
Ohio River:						
Cincinnati, Ohio	2	0	2	8	3	11
Louisville, Ky	1	0	1	7	7	14
Cairo, Ill	2	0	2	12	6	18
Platte River:						
Plattsmouth, Nebr	9	6	15	31	21	52
Rainy River:						
International Falls, Minn	0	0	0	1	8	9
Red River North:						
Grand Forks, N. Dak	2	0	2	13	15	28
South Platte River:						
Julesburg, Colo	1	34	35	7	57	64
Yellowstone River:						
Sidney, Mont	8	1	9	45	13	58
Maximum	12	34	35	59	57	72
Minimum	0	0	0	0	2	2

[a] Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides.

activity per gram of solids for all stations in each of the basin surveillance systems for 1961 through 1965 has been presented (7). Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these individual values are significantly high, comment will be made.

During April 1969, the following stations showed alpha radioactivity values in excess of 15 pCi/liter in dissolved solids:

North Platte River; Henry, Nebr.
South Platte River; Julesburg, Colo.

During April 1969, no station showed beta radioactivity values in excess of 150 pCi/liter in either suspended or dissolved solids.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data, PHS publication No. 663, 1958 edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(*2*) *Ibid*., 1959 Edition.

(*3*) *Ibid*., 1960 Edition

(*4*) *Ibid*., 1961 Edition.

(*5*) *Ibid*., 1962 Edition.

(*6*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system. annual compilation of data, PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(*7*) JULIAN, E. C. Gross radioactivity of the solids in selected surface waters of the United States, 1961–1965. Radiol Health Data Rep 9: 1–15 (January 1968).

Radioactivity in Minnesota Municipal Supplies[1] July-December 1968

Division of Environmental Sanitation
Minnesota Department of Health

The analysis of various Minnesota waters for radioactivity was initiated in 1956 as part of the Minnesota Water Pollution Control Program. This program was expanded in 1958 to include most of the municipal surface water supplies in the State, as well as selected lakes throughout the State.

As many as 25 surface streams and lakes involving 74 stations have been sampled. At present, nine surface streams and lakes used as municipal water supplies are sampled routinely (figure 1). "Grab" samples of raw and treated water are collected weekly at Hallock, East Grand Forks, Eveleth, Fairmont, and St. Paul, and monthly at Crookston, International Falls, and St. Cloud. Minneapolis tap water is analyzed weekly. No raw water is collected from the Minneapolis supply.

The samples are forwarded to the Division's laboratory, where they are analyzed for gross alpha and gross beta radioactivity. A 250-ml sample of water is transferred to a 2-inch planchet and evaporated at 75°C. The solid residue (suspended-plus-dissolved solids) is fixed by adding lucite in acetone. The sample is then counted for alpha or beta radioactivity in an internal-proportional counter. Counter standardization is accomplished by adding known amounts of thallium-204 standard to solutions containing the normal range of solids.

Table 1 shows a summary of the monthly average

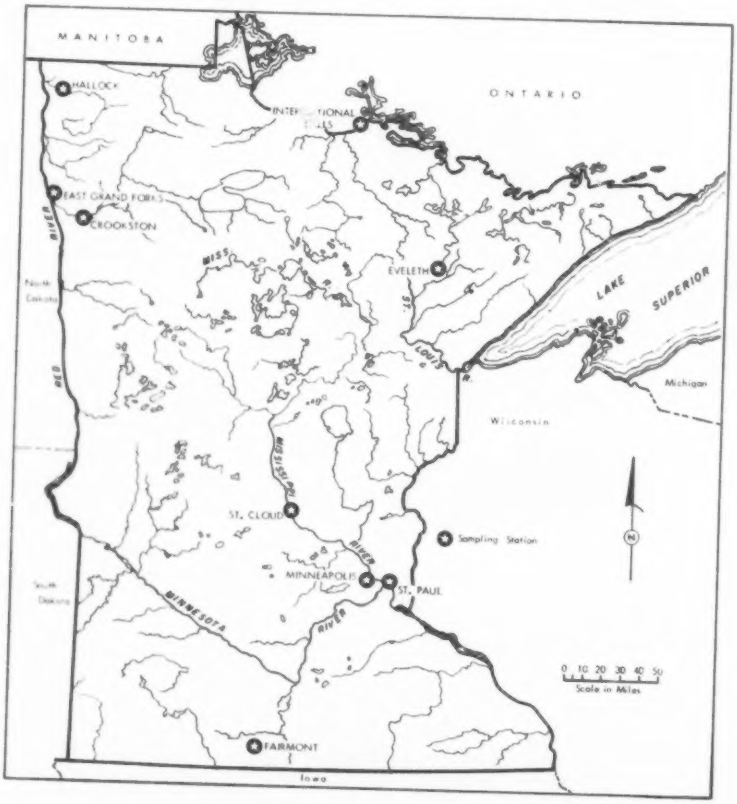
MANITOBA
ONTARIO
HALLOCK
INTERNATIONAL FALLS
EAST GRAND FORKS
CROOKSTON
RED RIVER
MISS
EVELETH
ST. LOUIS
LAKE SUPERIOR
Michigan
Wisconsin
North Dakota
South Dakota
MISSISSIPPI RIVER
ST. CLOUD
MINNEAPOLIS
ST. PAUL
MINNESOTA RIVER
Sampling Station
N
0 10 20 30 40 50
Scale in Miles
FAIRMONT
Iowa

Figure 1. Minnesota surface water sampling locations

Table 1. Total alpha radioactivity in Minnesota raw and treated water supplies, July–December 1968

Town and water source	Type of water	Average concentration (pCi/liter)					
		July	Aug	Sept	Oct	Nov	Dec
Crookston, Red Lake River	Raw	<1	<1	<1	2	2	<1
	Treated	<1	<1	3	<1	<1	<1
East Grand Forks, Red Lake River	Raw		<1 (2)[a]	3 (4)	2 (4)	2 (4)	<1 (4)
	Treated		<1 (2)	2 (4)	1 (5)	<1 (4)	<1 (4)
Eveleth, St. Mary's Lake	Raw	<1 (5)	<1 (4)	<1 (4)	<1 (4)	<1 (4)	<1 (4)
	Treated	<1 (5)	<1 (4)	<1 (4)	<1 (4)	<1 (4)	<1 (4)
Fairmont, Budd Lake	Raw	3 (5)	2 (5)	4 (3)	4 (5)	5 (3)	4 (4)
	Treated	1 (5)	<1 (5)	<1 (3)	2 (4)	1 (3)	1 (4)
Hallock, Two Rivers South Fork	Raw	2 (5)	<1 (4)	1 (4)	2 (5)	1 (4)	<1 (4)
	Treated	1 (5)	<1 (4)	<1 (4)	1 (5)	<1 (4)	2 (4)
International Falls, Rainy River	Raw	<1	<1	<1	<1	<1	1
	Treated						
Minneapolis tap water	Raw	<1	<1	<1	2	<1	1
	Treated	<1 (5)	<1 (4)	<1 (4)	<1 (4)	<1 (4)	<1 (5)
St. Cloud, Mississippi River	Raw	1	2	<1	<1	1	<1
	Treated	1	<1	<1	1	<1	<1
St. Paul, Vadnais Chain of Lakes	Raw	<1 (5)	1 (4)	<1 (4)	<1 (5)	<1 (4)	1 (4)
	Treated	<1 (5)	<1 (4)	<1 (4)	2 (5)	<1 (4)	<1 (4)

[a] Number in parentheses gives number of samples averaged.

Table 2. Total beta radioactivity in Minnesota raw and treated water supplies, July–December 1968

Town and water source	Type of water	Average concentration (pCi/liter)					
		July	Aug	Sept	Oct	Nov	Dec
Crookston, Red Lake River	Raw	20	23	22	19	19	18
	Treated	24	19	24	19	16	22
East Grand Forks, Red Lake River	Raw		16 (2)[a]	30 (4)	15 (5)	17 (4)	22 (4)
	Treated		9 (2)	15 (4)	10 (5)	8 (4)	9 (4)
Eveleth, St. Mary's Lake	Raw	16 (5)	14 (4)	10 (4)	12 (4)	12 (4)	12 (4)
	Treated	14 (5)	15 (4)	11 (4)	13 (4)	11 (4)	13 (4)
Fairmont, Budd Lake	Raw	13 (5)	12 (5)	24 (3)	13 (5)	10 (3)	13 (4)
	Treated	11 (5)	8 (5)	6 (3)	12 (4)	5 (3)	7 (4)
Hallock, Two Rivers South Fork	Raw	23 (5)	20 (4)	23 (4)	22 (5)	20 (4)	23 (4)
	Treated	9 (5)	8 (4)	12 (4)	10 (5)	7 (4)	8 (4)
International Falls, Rainy River	Raw	10	9	10	9	9	7
	Treated	10	7	9	6	8	7
Minneapolis tap water	Raw						
	Treated	6 (5)	4 (4)	6 (4)	9 (4)	3 (4)	6 (5)
St. Cloud, Mississippi River	Raw	12	5	9	10	10	9
	Treated	6	2	6	10	5	3
St. Paul, Vadnais Chain of Lakes	Raw	10 (5)	10 (4)	10 (4)	11 (5)	11 (4)	13 (4)
	Treated	6 (5)	8 (4)	7 (4)	9 (5)	7 (4)	7 (4)

[a] Number in parentheses gives number of samples averaged.

gross alpha radioactivity in Minnesota municipal water supplies from July–December 1968. Table 2 shows the gross beta radioactivity in the same samples for the same period of time. Alpha radioactivity reported as <1 pCi/liter were considered as 0.5 pCi/liter for averaging purposes.

The data obtained on gross beta radioactivity in Minnesota surface waters show a variation of concentrations, with no readily apparent trends. Variations in precipitation and flow rates of streams could contribute to this fluctuation. Monthly averages of gross beta radioactivity in Minnesota raw surface waters ranged from 5 to 30 pCi/liter, which is well below the Public Health Service Drinking Water Standards (*1*).

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[1] Data and information from "Survey of Environmental Radioactivity, July–December 1968," Publication No. COO-651-72 State of Minnesota Department of Health, University Campus, Minneapolis, Minn. 55440.

REFERENCE

(*1*) PUBLIC HEALTH SERVICE. Drinking water standards, Revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1968	February 1969

Radiostrontium in Tap Water July-December 1968[1]

Health and Safety Laboratory
U.S. Atomic Energy Commission

The Health and Safety Laboratory has performed analyses for strontium-90 in tap water at New York City since August 1954. Samples of tap water are collected daily so that by the end of the month a composite of at least 100 liters is available for analysis. Cesium-137 determinations were begun in January 1964. The analytical methods used at the laboratory are given in the Health and Safety Laboratory Manual of Standard Procedures (*1*).

Strontium-90 concentration and cesium-137 to strontium-90 ratios in New York City tap water for July through December 1968 are presented in table 1. These results appear graphically in figure 1.

A decreasing trend has been observed in the strontium-90 concentrations since the July 1963 peak. The maximum strontium-90 concentrations observed are below the acceptable limit as set forth in the interstate carrier drinking water standards (*2*).

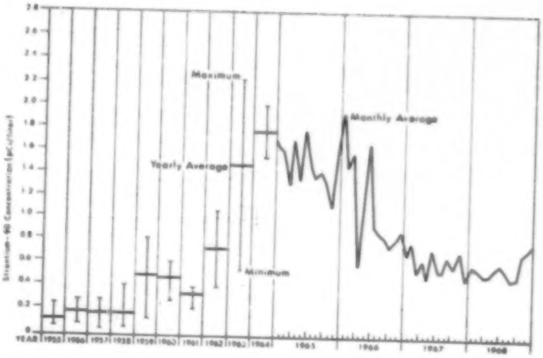

Figure 1. Strontium-90 concentrations in New York City tap water, 1955–December 1968

Table 1. Radiostrontium in New York City tap water July-December 1968

Sampling months (1968)	Strontium-90[a] (pCi/liter)	Cesium-137/strontium-90
July	0.54	0.14
August	.46	.12
September	.48	.11
October	.68	.08
November	.72	.08
December	.77	.07

[a] Approximately 100 liters per sample.

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[1] Prepared from information appearing in Fallout Program Quarterly Summary Report, HASL 210. This report is available from the Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Va. 22151.

REFERENCES

(*1*) U.S. ATOMIC ENERGY COMMISSION. Manual of standard procedures 40:E-38-01-16 Health and Safety Laboratory, U.S. Atomic Energy Commission, 376 Hudson Street, New York, N. Y. 10014.

(*2*) FEDERAL REGISTER RULES AND REGULATIONS. TITLE 42-Public Health, Chapter 1, Public Health Service, Department of Health, Education and Welfare; Part 72, Interstate Quarantine, Subpart J. Drinking Water Standards 27:2154-2155. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 6, 1962).

Tritium in Surface Water Network January-June 1969

Bureau of Radiological Health
U.S. Public Health Service

The tritium sampling network was established by the Public Health Service in May 1964, to measure and monitor tritium concentrations in major river systems in the United States and to provide surveillance at selected surface water stations downstream from nuclear facilities. The network consists of 10 stations selected from the 131 existing water pollution sampling stations operated by the Federal Water Pollution Control Administration (FWPCA); eight of the stations are located downstream from nuclear facilities and two stations serve to establish baseline levels (figure 1). Reports covering the period, 1964–1965 (*1*) and 1966 (*2*) have been published previously in *Radiological Health Data and Reports*.

Monthly composites of weekly samples are collected through the FWPCA and sent to the Southeastern Radiological Health Laboratory for analysis. The analyses are carried out using liquid scintillation counting techniques described by Moghissi et al (*3*). The minimum level of detectability is 0.2 nCi/liter.

Data for the samples collected during the first 6 months of 1969 are shown in table 1. Station averages for this period and the corresponding period of 1968 are also presented in the table. The highest concentration observed during the first 6 months of 1969 was 22.0 nCi/liter (Clinch River —Kingston, Tenn.). The highest 6 month average, 14.4 nCi/liter, was also observed at the Clinch River station. Assuming that the specific activity of tritium in the body is essentially the same as that in the surface water, this average concentration corresponds to an estimated whole-body dose[1]

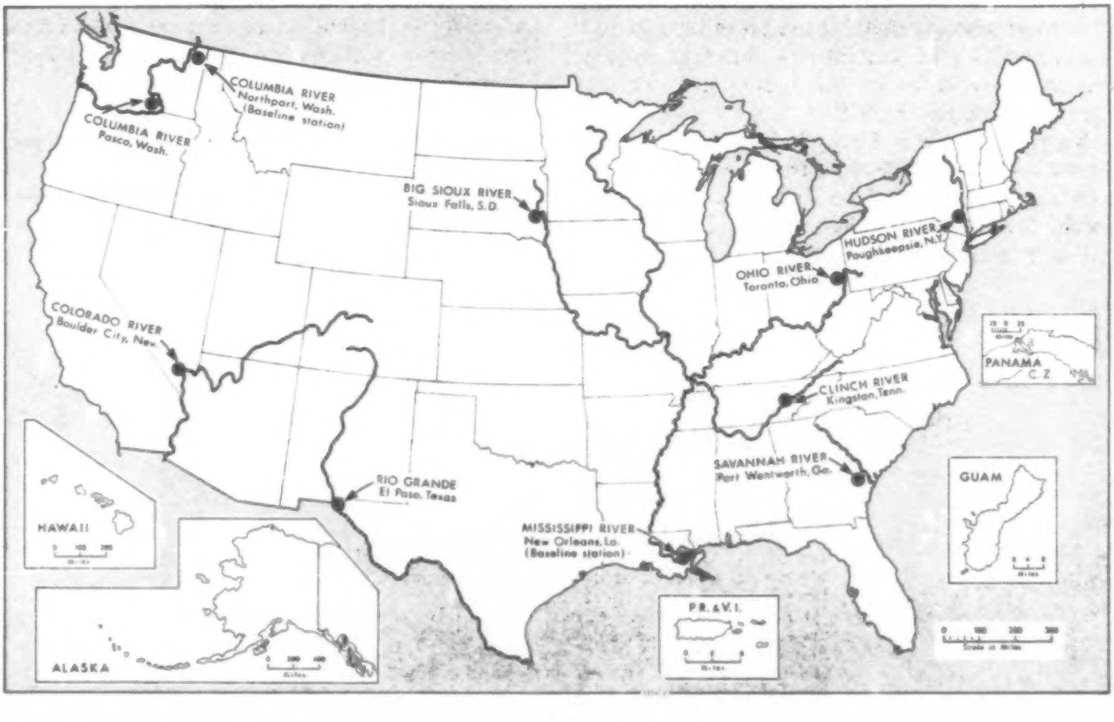
COLUMBIA RIVER Northport, Wash. (Baseline station)
COLUMBIA RIVER Pasco, Wash.
BIG SIOUX RIVER Sioux Falls, S.D.
HUDSON RIVER Poughkeepsie, N.Y.
OHIO RIVER Toronto, Ohio
COLORADO RIVER Boulder City, Nev.
CLINCH RIVER Kingston, Tenn.
SAVANNAH RIVER Port Wentworth, Ga.
RIO GRANDE El Paso, Texas
MISSISSIPPI RIVER New Orleans, La. (Baseline station)
PANAMA C.Z
GUAM
HAWAII
ALASKA
P.R. & V.I.

Figure 1. Sampling stations for tritium in surface waters

Table 1. Tritium concentration in surface waters, January–June 1969

Collection site	Concentration[a] (nCi/liter)							
	January	February	March	April	May	June	January–June average[b]	
							1969	1968
Clinch River, Kingston, Tenn.	NS	NS	NS	22.0 ± 0.5	15.9 ± 0.4	5.4 ± 0.3	14.4	4.4
Colorado River, Boulder City, Nev.	[c] <0.2	2.0 ± 0.1	1.4 ± 0.3	1.7 ± .2	1.5 ± .2	1.5 ± .2	1.4	2.6
Columbia River, Northport, Wash.[d]	NS	1.0 ± .3	1.0 ± .3	NS	.9 ± .2	NS	1.0	1.7
Columbia River, Pasco, Wash.	NS	.8 ± .2	NS	1.3 ± .2	.9 ± .2	1.0 ± .2	1.0	1.5
Hudson River, Poughkeepsie, N.Y.	0.8 ± .2	.4 ± .2	< .2	< .2	.4 ± .2	.6 ± .2	.4	1.1
Mississippi River, New Orleans, La.[d]	< .2	< .2	.4 ± .2	< .2	.4 ± .2	.6 ± .2	.2	.7
Ohio River, Wheeling, W.Va.	.2 ± .2	.4 ± .2	.4 ± .2	.4 ± .2	.3 ± .2	NS	.3	.8
Rio Grande, El Paso, Tex.	< .2	< .2	.2 ± .2	< .2	.3 ± .2	.2 ± .2	.1	.7

[a] The error reported is the two-sigma error at the 95 percent confidence level.
[b] Values less than or equal to the minimum level of detectability (0.2 nCi/liter) were averaged as zero.
[c] Values are not statistically significant at the 95 percent confidence level.
[d] Baseline station.
NS, no sample.

of 2.4 mrem/year; or in terms of Federal Radiation Council guidance, less than 2 percent of the Radiation Protection Guide (170 mrem/year) for an average dose to a suitable sample of the exposed population (*4*). In general, the 6-month station averages were lower for this period than for the comparable period in 1968.

Sampling at Sioux Falls, S. Dak., was discontinued in October 1968 since the reactor there was no longer operational. The station at Port Wentworth, Ga., was also discontinued due to difficulties in locating a new sampling point.

This present program is being terminated as of July 1, 1969. A new program will then be initiated in which drinking water samples will be collected and analyzed for tritium on an annual basis from the present stations of the Radiation Alert Network.

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[1] Development of the calculations to obtain this dose may be found in reference (*2*).

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January–June 1968	November 1968
July–December 1968	June 1969

REFERENCES

(*1*) CHESNUTT, M. W., J. C. DROBINSKI, Jr., and R. H. GORRIE. Tritium in surface waters, 1964–1965. Radiol Health Data Rep 7:377–380 (1966).

(*2*) MOGHISSI, A. A., and C. R. PORTER. Tritium in surface waters in the United States, 1966. Radiol Health Data Rep 9:337–339 (1968).

(*3*) MOGHISSI, A. A., H. L. KELLEY, J. E. REGNIER, and M. W. CARTER. Low-level counting by liquid scintillation. I. tritium measurement in homogeneous systems. Inter J. Appl Rad Isotopes 20:145 (1969).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1 (May 13, 1960). Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta-radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports*.

Network	Period	Issue
HASL 80th Meridan Network	Calendar Year 1966	December 1968
Fallout in the United States and Other areas, *HASL*	January–June 1968	October 1969
Plutonium in Airborne Particulates and Precipitation	April–June 1968	October 1969

1. Radiation Alert Network
July 1969

Bureau of Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Bureau of Radiological Health officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Radiological Surveillance Branch, Division of Environmental Radiation, BRH, Rockville, Md. A detailed description of the sampling and analytical procedures was presented in the April 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during July 1969. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.

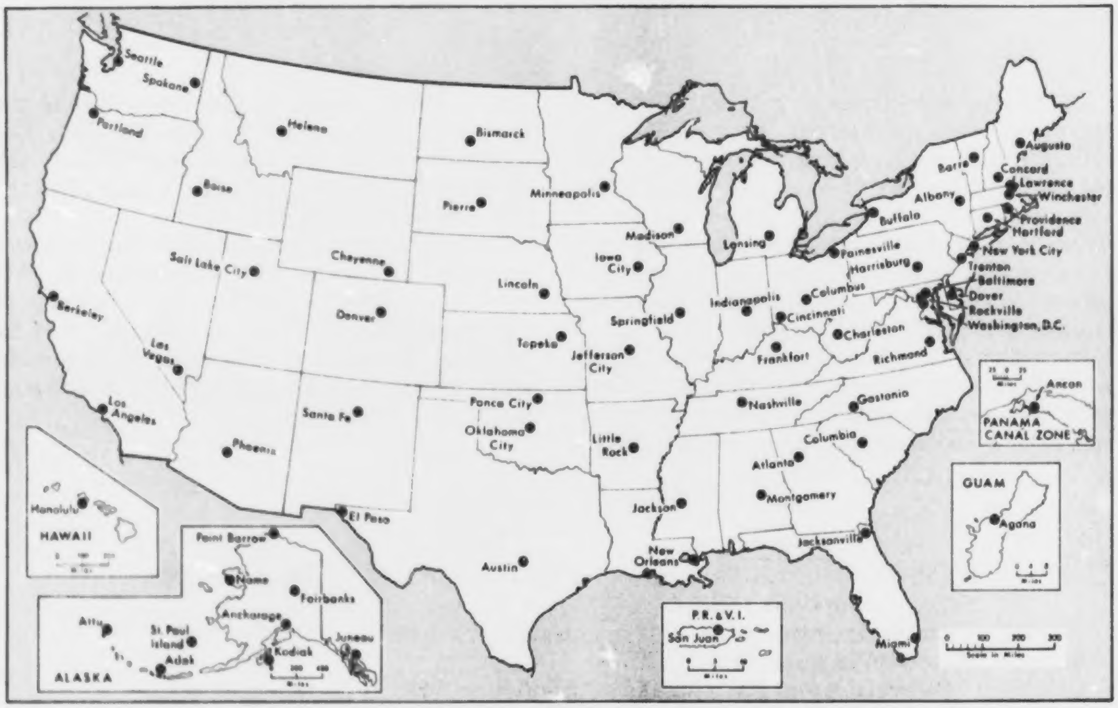
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Salt Lake City
Cheyenne
Lincoln
Denver
Berkeley
Las Vegas
Topeka
Los Angeles
Santa Fe
Phoenix
Ponca City
Oklahoma City
El Paso
Austin
Madison
Iowa City
Springfield
Jefferson City
Little Rock
Jackson
New Orleans
Lansing
Indianapolis
Columbus
Cincinnati
Frankfort
Charleston
Nashville
Atlanta
Montgomery
Jacksonville
Miami
Columbia
Gastonia
Richmond
Painesville
Harrisburg
Buffalo
Albany
Barre
Augusta
Concord
Lawrence
Winchester
Providence
Hartford
New York City
Trenton
Baltimore
Dover
Rockville
Washington, D.C.
Ancon
PANAMA CANAL ZONE
GUAM
Agana
P.R. & V.I.
San Juan
Honolulu
HAWAII
Point Barrow
Nome
Fairbanks
Anchorage
Attu
St. Paul Island
Adak
Kodiak
Juneau
ALASKA
Scale in Miles

Figure 1. Radiation Alert Network sampling stations

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Table 1. Gross beta radioactivity in surface air and precipitation, July 1969

Station location		Number of samples	Air surveillance gross beta radioactivity (pCi/m^3)			Last profile in RHD&R	Precipitation				
							Number of samples	Total depth (mm)	Field estimation of deposition		
		Air	Maximum	Minimum	Average[a]				Number of samples	Depth (mm)	Total deposition (nCi/m^2)
Ala:	Montgomery	21	7	0	2	July 69	8	113	8	113	52
Alaska:	Adak	(b)				Feb 69	(c)				
	Anchorage	8	0	0	0	Aug 69	(c)				
	Attu Island	19	1	0	0	Mar 69	(c)				
	Fairbanks	(b)				Sept 69	(c)				
	Juneau	22	4	0	1	Oct 69	15	255	15	255	2
	Kodiak	3	0	0	0	Nov 69	(c)				
	Nome	(b)				May 69	(c)				
	Point Barrow	31	0	0	0	Apr 69	(c)				
	St. Paul Island	6	1	1	1	June 69	(c)				
Ariz:	Phoenix	18	9	1	3	Oct 69	(c)				
Ark:	Little Rock	8	6	2	4	Aug 69	(c)				
Calif:	Berkeley	21	1	0	0	Nov 69	(c)				
	Los Angeles	21	5	0	1	May 69	(c)				
C.Z:	Ancon	16	0	0	0	Nov 69	(c)				
Colo:	Denver	17	7	2	4	Nov 69	(c)				
Conn:	Hartford	19	2	0	1	Sept 69	8	86	6	77	1
Del:	Dover	20	2	0	1	July 69	(c)				
D.C.:	Washington	28	2	0	0	Apr 69	8	256	8	256	141
Fla:	Jacksonville	18	1	0	0	Aug 69	10	147	10	147	58
	Miami	17	1	0	0	Sept 69	7	202	7	202	0
Ga:	Atlanta	21	2	1	1	June 69	1	13	1	13	10
Guam:	Agana	(b)				July 69	(c)				
Hawaii:	Honolulu	27	1	0	0	Mar 69	2	13	(d)		
Idaho:	Boise	21	3	1	2	Mar 69	(c)				
Ill:	Springfield	21	4	0	1	Apr 69	(c)				
Ind:	Indianapolis	18	5	0	1	June 69	8	215	8	215	21
Iowa:	Iowa City	18	3	0	1	Nov 69	7	177	7	177	0
Kans:	Topeka	21	5	1	2	Aug 69	9	125	9	125	12
Ky:	Frankfort	15	4	1	2	Apr 69	(c)				
La:	New Orleans	18	1	0	1	Apr 69	14	126	(d)		
Maine:	Augusta	(b)				Oct 69	(c)				
Md:	Baltimore	19	2	0	1	Sept 69	4	40	4	40	21
	Rockville	12	1	0	1	Mar 69	(c)				
Mass:	Lawrence	20	2	0	1	Nov 69	5	53	5	53	7
	Winchester	21	1	0	1	Feb 69	6	77	6	77	0
Mich:	Lansing	19	2	0	1	Mar 69	8	95	8	95	12
Minn:	Minneapolis	21	3	0	1	July 69	6	72	6	72	52
Miss:	Jackson	16	3	0	1	Oct 69	6	93	5	80	4
Mo:	Jefferson City	22	5	0	1	June 69	8	77	8	77	3
Mont:	Helena	20	6	1	3	Feb 69	2	16	2	16	9
Nebr:	Lincoln	17	8	2	4	June 69	3	92	2	42	11
Nev:	Las Vegas	18	4	1	2	Sept 69	(c)				
N.H.:	Concord	21	3	0	1	Apr 69	(c)				
N.J:	Trenton	21	3	0	1	Oct 69	9	169	9	169	20
N. Mex:	Santa Fe	13	3	0	1	Feb 69	4	37	4	37	10
N.Y:	Albany	(b)				June 69	(c)				
	Buffalo	21	2	0	1	Nov 69	(c)				
	New York City	20	1	0	1	Feb 69	(c)				
N.C:	Gastonia	15	10	2	5	Nov 69	4	38	(d)		
N. Dak:	Bismarck	21	5	1	2	Apr 69	7	149	7	149	2
Ohio:	Cincinnati	(b)				July 69	(c)		(e)		
	Columbus	14	3	0	2	Oct 69	4	102			
	Painesville	20	5	0	1	Sept 69	7	264	7	264	88
Okla:	Oklahoma City	21	4	0	2	Mar 69	1	22	1	22	1
	Ponca City	23	4	1	2	Sept 69	5	56	5	56	1
Ore:	Portland	18	1	0	1	June 69	1	1	1	1	0
Pa:	Harrisburg	6	2	0	1	June 69	(c)				
P.R:	San Juan	(b)				Oct 69	(c)				
R.I:	Providence	18	2	0	1	Mar 69	7	107	7	107	12
S.C:	Columbia	19	4	0	2	Feb 69	6	145	6	145	4
S. Dak:	Pierre	17	7	0	4	Oct 69	(c)				
Tenn:	Nashville	20	2	0	1	Mar 69	4	176	4	176	4
Tex:	Austin	19	11	1	4	July 69	2	4	(d)		
	El Paso	(b)				Apr 69	(c)				
Utah:	Salt Lake City	31	4	1	2	May 69	2	36	2	36	10
Vt:	Barre	19	5	0	2	Aug 69	9	102	9	102	146
Va:	Richmond	20	3	0	1	Aug 69	9	231	9	231	28
Wash:	Seattle	7	0	0	0	Aug 69	2	5	(d)		
	Spokane	14	3	1	2	July 69	(c)				
W. Va:	Charleston	20	5	1	2	Feb 69	9	115	9	115	12
Wisc:	Madison	20	2	0	1	Aug 69	9	106	9	106	16
Wyo:	Cheyenne	21	7	1	3	Sept 69	2	8	2	8	2
Network summary		1,177	11	0	2		7	120	6	110	22

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] No report received. (Air samples received without field estimate data are not considered by the data program.)
[c] No precipitation sample collected.
[d] This station is part of the plutonium in precipitation network. No gross beta measurements are done.
[e] Samples were collected but no field estimates were received.

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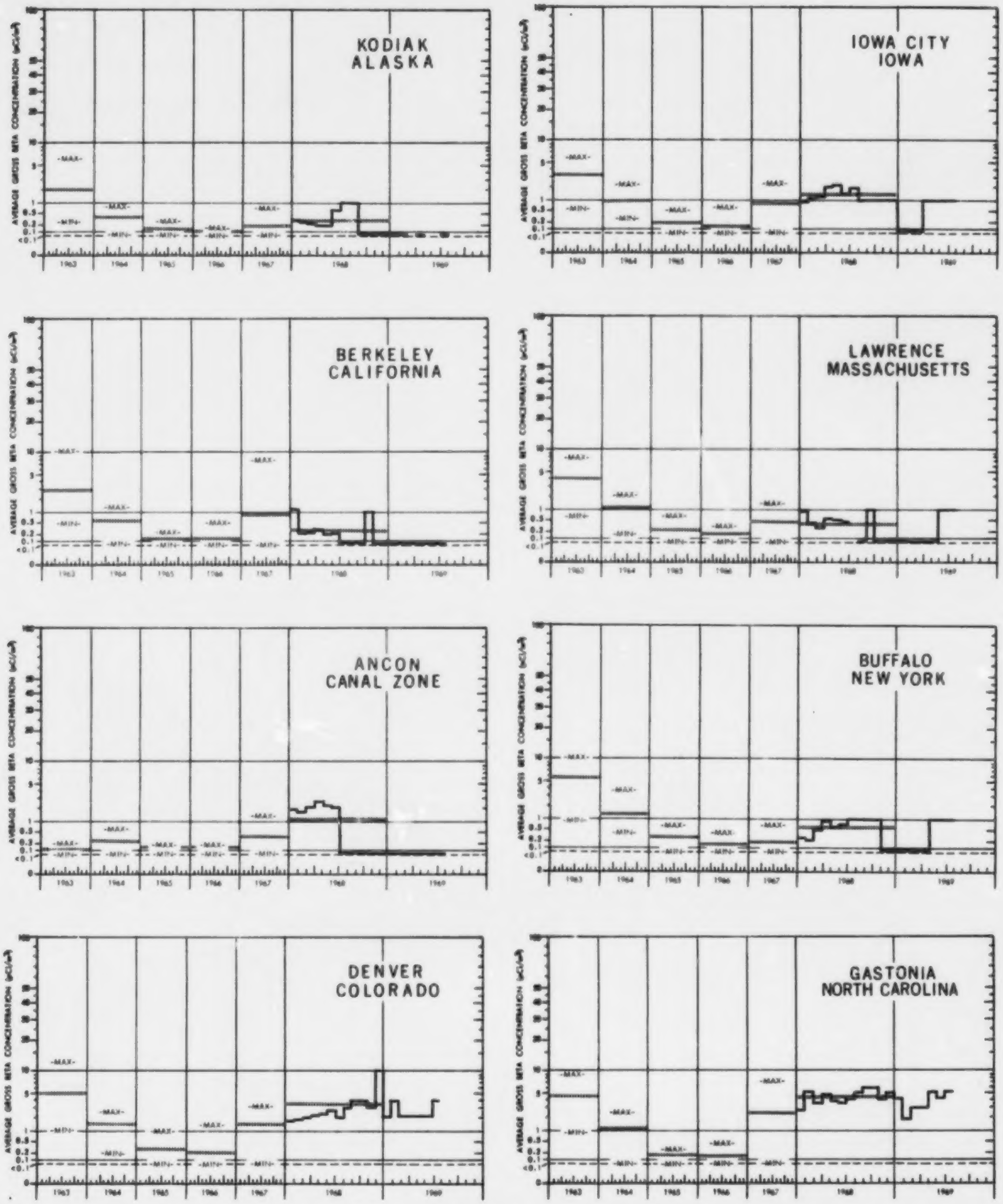

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network, 1963-July 1969

2. Canadian Air and Precipitation Monitoring Program[1] July 1969

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meterological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports*.

Surface air and precipitation data for July 1969 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, July 1969

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	NS				8.4	6.3
Coral Harbour	31	0.5	0.0	0.2	NS	NS
Edmonton	31	.5	.0	.3	176	16.2
Ft. Churchill	30	.4	.0	.2	183	5.1
Ft. William	31	.6	.1	.2	279	11.0
Fredericton	30	.5	.0	.2	72	9.9
Goose Bay	31	.4	.0	.1	26	2.2
Halifax	29	.6	.1	.2	100	11.1
Inuvik	31	.3	.0	1	162	4.4
Montreal	31	.6	.0	.3	85	5.1
Moosonee	31	.5	.1	.3	56	5.2
Ottawa	31	.6	.0	.3	39	4.5
Quebec	31	.5	.1	.2	104	13.4
Regina	31	.7	.0	.3	224	16.4
Resolute	26	.4	.0	.1	33	1.8
St. John's, Nfld	30	.4	.0	.1	113	11.2
Saskatoon	31	.5	.0	.3	140	8.8
Saulte Ste Marie	31	.7	.1	.3	284	8.0
Toronto	30	.4	.1	.3	107	9.1
Vancouver	31	.4	.0	.2	112	1.9
Whitehorse	31	.5	.0	.2	76	5.1
Windsor	31	.5	.1	.3	49	11.9
Winnipeg	31	.7	.1	.3	204	20.7
Yellowknife	31	.5	.0	.2	263	3.3
Network summary	31	0.5	0.0	0.2	130	8.4

NS, no sample.

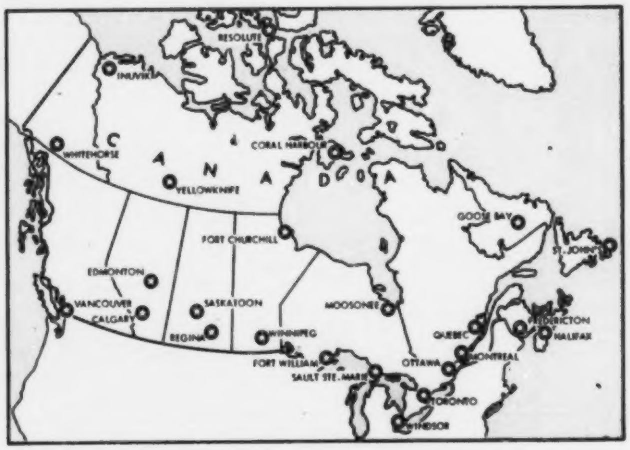
RESOLUTE
INUVIK
C A N A D A
COTAL HARBOUR
WHITEHORSE
YELLOWKNIFE
GOOSE BAY
ST. JOHN'S
FORT CHURCHILL
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
FREDERICTON
HALIFAX
QUEBEC
OTTAWA
MONTREAL
FORT WILLIAM
SAULT STE. MARIE
TORONTO
WINDSOR

Figure 3. Canadian air and precipitation sampling stations

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[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

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3. Mexican Air Monitoring Program
November–December 1968

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potosì; and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Prevision del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosì, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air

Table 3. Mexican gross beta radioactivity of airborne particulates, November 1968

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	NS			
Chihuahua	4	0.4	0.1	0.2
Ciudad Juares	NS			
Ensenada	7	.2	.1	.1
La Paz	4	.6	.1	.2
Matamoros				
Mazatlan	NS			
Mérida	11	.4	.1	.2
México, D.F	9	.3	.1	.2
Nuevo Laredo	7	.3	.1	.2
Tampico	4	.2	.1	.1
Torreón	14	.2	.1	.1
Veracruz	9	.4	<.1	.1

NS, no sample, station temporarily shut down.

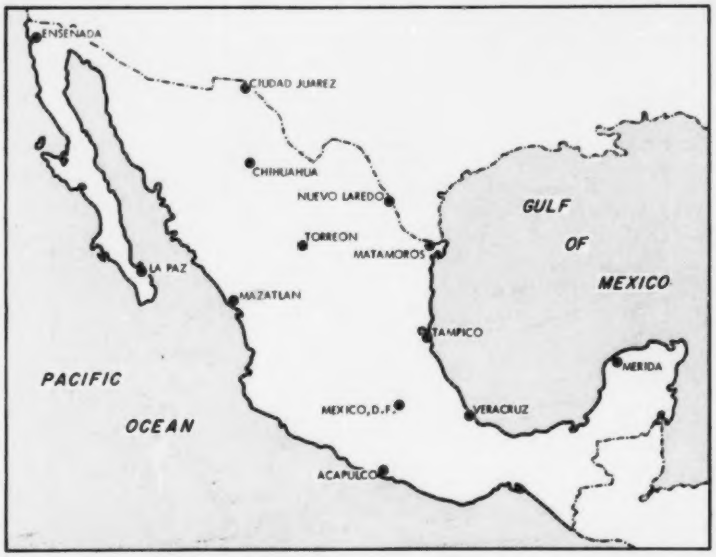

Figure 4. Mexican air sampling locations

through a high-efficiency 6- by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high volume samplers.

After each 20 hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron daughters. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of five samples per month were needed to get a reliable average radioactivity at each station (*1*).

The maximum, minimum, and average beta radioactivity in surface air during November and December 1968 are presented in tables 3 and 4.

Table 4. Mexican gross beta radioactivity of airborne particulates, December 1968

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	NS			
Chihuahua	13	0.3	0.1	0.2
Ciudad Juarez	10	.4	.1	.2
Ensenada	3	.2	.1	.1
La Paz	3	.2	.1	
Matamoros	NS			
Mazatlan	NS			
Mérida	12	.3	.1	.2
México, D.F.	7	.5	.1	.2
Nuevo Laredo	7	.3	.1	.1
Tampico	NS			
Torreón	15	.4	.1	.2
Veracruz	NS			

NS, no sample, station temporarily shut down.

4. Pan American Air Sampling Program July 1969

Pan American Health Organization and
U.S. Public Health Service

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO member countries in developing radiological health programs.

The air sampling locations are shown in figure 5.

Analytical techniques were described in the January 1968 issue of *Radiological Health Data and Reports*. The July 1969 air monitoring results from the participating countries are given in table 5.

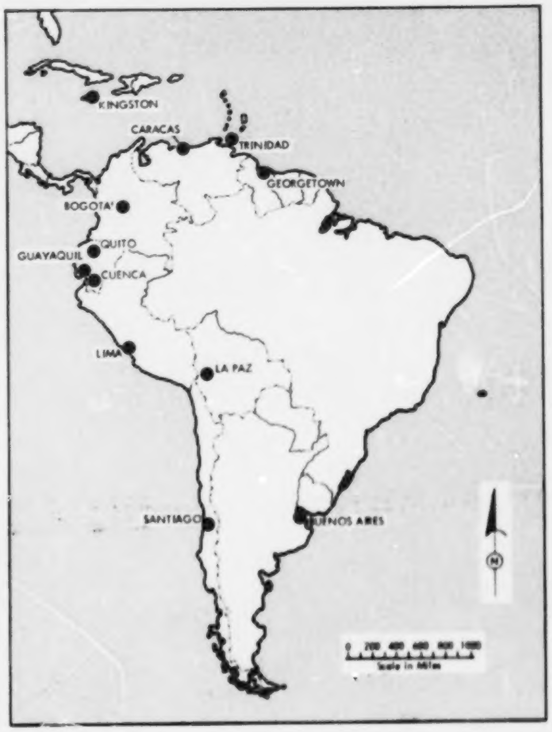

Figure 5. Pan American Air Sampling Program stations

Table 5. Summary of gross beta radioactivity in Pan American surface air, July 1969

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	NS			
Bolivia:	La Paz	14	0.29	0.06	0.13
Chile:	Santiago	26	.31	.06	.14
Colombia:	Bogota	17	.04	.00	.01
Ecuador:	Cuenca	12	.02	.00	.01
	Guayaquil	18	.12	.02	.06
	Quito	17	.03	.00	.01
Guyana:	Georgetown	26	.26	.01	.09
Jamaica:	Kingston	17	.68	.06	.25
Peru:	Lima	4	.14	.03	.08
Venezuela:	Caracas	20	.43	.01	.09
West Indies:	Trinidad	15	.31	.04	.15
Pan American summary		186	0.68	0.00	0.10

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

NS, no sample.

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(*6*) VASQUEZ, M. and R. M. DE NULMAN. Estudios sobre la radioactividad ambiental en la República Mexicana, 1963-1965. Comisión Nacional de Energía Nuclear, Dirección General de Seguridad Radiologica (1966).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, bovine thyroid sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Iodine-131 in Bovine Thyroid
January-February 1969

Bureau of Radiological Health
Public Health Service

The Bureau of Radiological Health (formerly the National Center for Radiological Health) established a bovine thyroid network in October 1964 (*1*). Specimens are collected by the Livestock Slaughter Inspection Division, U.S. Department of Agriculture, and are analyzed by gamma-ray spectroscopy for iodine-131 content at the Northeastern Radiological Health Laboratory, Winchester, Mass.

The network consists of collection areas (counties shaded in figure 1) located so as to cover, as nearly as possible, areas near major nuclear reactors, spent-fuel reprocessing plants and nuclear test sites. Details of sampling and analyses have been published earlier (*1*).

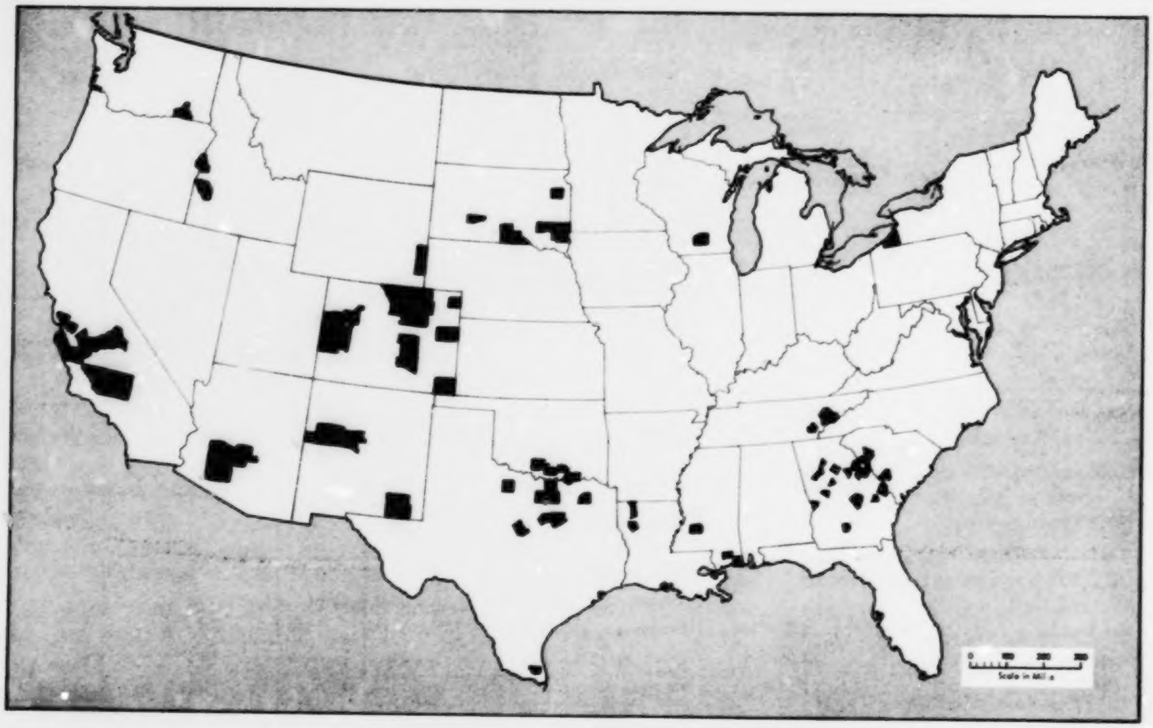

Figure 1. Sampling locations for Bovine Thyroid Network

The results for January through February 1969 appear in table 1 and are listed by county alphabetically within each State. Moderate elevations in radioactivity were found in 10 States during this period. The two most active samples analyzed were collected in Delta County, Colo., and Washington County, Idaho, on January 3. They contained 23 and 36 pCi iodine-131/g thyroid, respectively.

Due to the very low levels of radioactivity detected in this network, this program is discontinued as of March 1, 1969. If levels of iodine-131 in the environment increase significantly in the future, provisions have been made to sample bovine thyroids at that time.

REFERENCE

(*1*) BARATTA, E. J., E. R. WILLIAMS, and G. MURRAY. Iodine-131 in bovine thyroids, October–December 1964. Radiol Health Data 6:569–571 (October 1965).

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July–September 1968	February 1969
October–December 1968	April 1969

Table 1. Iodine-131 in bovine thyroids, January–February 1969

State	Date(s) of slaughter	County	Number of samples	pCi iodine-131/g thyroid		
				Average or concentration	Minimum	Maximum
Arizona	1/2-2/20[a]	Maricopa	11	0		
California	1/13-2/7[a]	Fresno (2)[b]	18	0		
		Kern (1)				
		Monterey (10)				
		Santa Clara (5)				
Colorado	1/13-2/10[a]	Adams (4)[b]	9	[c]0		
		Arapahoe (1)				
	1/13-2/20[a]	Baca (2)				
	1/6-2/20[a]	Boulder (2)				
		Delta	27	1	0	23
		El Paso	7	0		
	1/8-1/28[a]	Garfield	27	1	0	24
	1/2	Kit Carson	9	[c]0		
	1/2-2/18[a]	Larimer (8)				
	2/13-2/20[a]	Mesa	17	[c]0		
		Montrose	8	1	0	9
	1/10-1/21[a]	Morgan (7)	12	0		
	1/6	Phillips (1)				
	1/16-2/18[a]	Pueblo (4)				
	1/2-2/17[a]	Weld (9)		1	0	8
Georgia	1/16-2/6[a]	Bibb	9	[c]0		
		Butts	12	1	0	8
	2/19	Candler	1	7		
	2/12-2/19[a]	Columbia (3)[b]	25	[c]0		
	1/22	Fulton (5)				
	1/8-2/12[a]	Greene (2)				
	1/22	Laurens (2)				
	1/22-2/19[a]	McDuffie (6)				
	1/29	Muscogee (3)				
	2/19	Screven (3)[b]				
	2/12	Upson (1)				
	1/16	Walton (3)[b]	16	[c]0		
	1/8	Warren (2)				
	1/8-2/19[a]	Wilkes (10)				
Idaho	1/17	Ada[b]	2	[c]0		
	1/3-1/24[a]	Canyon	6	3	0	7
		Washington	12	5	0	36
Louisiana	2/3	Bossier (1)[b]	2	0		
	2/7	Red River (1)				
Mississippi	1/9-2/13[a]	Copiah (2)[b]	9	0		
		Jackson (5)				
		Stone (2)				
New Mexico	1/7	Bernalillo (2)[b]	5	[c]0		
		Eddy (1)				
		Valencia (2)				
New York	1/7-2/13[a]	Chautauqua	50	0		
Oklahoma	1/17-2/24[a]	Bryan (2)[b]	5	[c]0		
		Carter (1)				
		Johnston (1)				
		Stephens (1)				

See footnotes at end of table.

Table 1. Iodine-131 in bovine thyroids, January–February 1969—Continued

State	Date(s) of slaughter	County	Number of samples	pCi iodine-131/g thyroid		
				Average or concentration	Minimum	Maximum
South Carolina	1/8–2/12[a]	Barnwell (1)[b] Greenwood (2) McCormick (1)	4	[c]0		
South Dakota	1/7–2/19[a]	Codington (6)[b] Davison (2) Gregory (10) Hanson (2) Jackson (2)	60	[c]0		
	1/7–2/19[a]	Lincoln (2) McCook (1) Minnehaha (17) Tripp (3) Turner (15)				
Tennessee	1/21–2/19[a]	Blout[b]	7	8	0	11
		Knox	1	7		
		McMinn (1)	7	[c]0		
		Sevier (6)				
Texas	1/6–2/24[a]	Baylor (1)[b] Comanche (1) Cooke (3) Denton (7) Ellis (1) Hopkins (1) Johnson (2) Willacy (3) Wise (1)	20	[c]0		
Washington	1/6–2/6	Walla Walla	10	0		
Wisconsin	1/10–2/24	Dane	33	0		
Wyoming	1/6–1/10	Goshen (1)[b] [e] (3)	4	6	0	14

[a] Samples were not collected on all dates during this period, but the interval includes several sampling dates.

[b] Numbers in parenthesis represent the number of samples collected from that county during the interval indicated. These may have been collected over several dates or only one date.

[c] The results for this period were for the most nondetectable. Some randomly scattered positive results were obtained; but these represented barely detectable amounts of iodine-131 in the bovine thyroid (2–5 pCi/g).

[d] All results ≤ 1 pCi/g are reported as 0.

[e] Name of county not available.

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Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for the Portsmouth Area Gaseous Diffusion Plant and the Savannah River Plant.

I. Portsmouth Area Gaseous Diffusion Plant[2] July–December 1968

Goodyear Atomic Corporation
Piketon, Ohio

The separation of uranium isotopes by the gaseous diffusion process presents control problems similar to any chemical process using toxic solvents and extraction solutions. Natural uranium and thorium-234 are the most likely radionuclides to be released to the environment by the Portsmouth Area Gaseous Diffusion Plant. To verify the effectiveness of plant controls, environmental monitoring is conducted for evidence of alpha-particle, beta-particle, and gamma-ray emitters.

Air samples are generally collected monthly at 21 sites located from 1 to 6 miles from the plant as shown in figure 1. Monthly water samples are collected at 13 stations within 5 miles of the plant.

For July–December 1968, the waterborne alpha and beta-gamma radioactivity and the background exposure increased over the first half of 1968. The airborne alpha and beta-gamma radioactivity remained essentially unchanged.

For the calendar year 1968 versus calendar year 1967, the water alpha and beta-gamma radioactivity increased significantly; however, the 1968 values are less than 1 percent of the AEC concentration standards. Airborne alpha and beta-gamma radioactivity remained essentially unchanged.

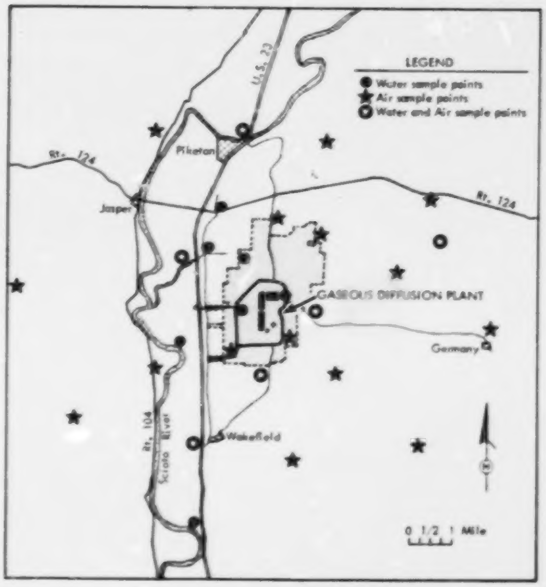

Figure 1. Sampling locations, Portsmouth Area Gaseous Diffusion Plant

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[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

[2] Data summarized from B. Kalman and S. H. Hulett, "Environmental Radiation Levels and Concentrations, Second Half and Annual Summaries 1968" (February 17, 1969)

Table 1. Environmental radioactivity, Portsmouth Plant July–December 1968

Type of monitoring	Number of samples	Maximum	Minimum	Average	Average as a percent of AEC standard[a]
Air:					
Alpha radioactivity (pCi/m^3)	125	1.2	< 0.1	0.1	5.2
Beta-gamma radioactivity (pCi/m^3)	125	3.6	.1	.2	.02
Water:					
Alpha radioactivity (pCi/liter)	81	1,215	< .5	76.7	.38
Beta-gamma radioactivity (pCi/liter)	81	2,205	<14.0	110.9	.55
Background exposure[b] (mrad/h)	125	.027	.010	.017	19.9

[a] The applicable radiation protection standards are as follows:

Air (alpha radioactivity)	2 pCi/m^3
Air (beta-gamma radioactivity)	1 nCi/m^3
Water (alpha radioactivity)	20 nCi/liter
External (beta–gamma radioactivity)	0.5 rem/a (approx. 0.6 mrad/h)

[b] Measurements were made with an open-shield Geiger–Mueller tube 1 foot above ground. The 3-foot rate (not shown) was experimentally determined to average two-thirds of the 1-foot rate and was used to determine the percent of the concentration standard.

Penetrating background dose rates were slightly higher when compared with the 1967 values. In the calculations it is assumed that all of the dose rates are attributable to plant operations. As in the past, the offsite and onsite patterns are very much alike in form and intensity with no significant differences between the average values. From the onsite and offsite intensities, it is evident that the plant operations have not added appreciably to the general background radiation.

Average alpha and beta-gamma radioactivity concentrations in air and water are summarized in table 1. The external gamma-ray levels, measured at the air sampling locations shown in figure 1, are also summarized in table 1. The overall average concentrations and background exposure rates for 1967 and 1968 are presented in table 2 as percent of standards.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1967	July 1968
January–June 1968	January 1969

Table 2. Comparison of average concentrations Portsmouth Plant, 1967 and 1968

Type of monitoring	Percent of AEC standard[a]			
	January–June 1968	July–December 1968	Calendar year 1968	Calendar year 1967
Air				
Alpha radioactivity	5.0	5.2	5.0	5.0
Beta-gamma radioactivity	.02	.03	.02	.01
Water				
Alpha radioactivity	.13	.38	.28	.08
Beta-gamma radioactivity	.27	.55	.43	.24
Background exposure extrapolated to 3 feet above ground level	16.2	19.9	18.3	17.3

[a] See footnote (a) of table 1.

2. Savannah River Plant[3]
July–December 1968

E. I. duPont de Nemours
Aiken, South Carolina

The Savannah River Plant (SRP), built and operated for the Atomic Energy Commission by E. I. duPont de Nemours and Company, occupies an area of 312 square miles along the Savannah River, 22 miles downstream from Augusta, Ga. Production facilities include a fuel preparation area, four reactors, two fuel separation areas, and a heavy water production plant. A basic goal in plant operation is total containment of radioactive waste. Although some very low level gaseous and liquid wastes are discharged to the environment in controlled releases, dispersal is adequate to ensure environmental concentrations below recommended guides.

The DuPont Environmental Monitoring Group has maintained a continuous monitoring program since 1951 (before plant startup) to determine the concentrations of radioactive materials in a 1,200 square mile area outside the plant. Included in this area are parts of Aiken, Barnwell, and Allendale counties in South Carolina, and Richmond, Burke, and Screven counties in Georgia. This surveillance determines the magnitude and origin of any radioactivity above natural levels. Measured concentrations of radionuclides in air, water, and milk are compared with the maximum permissible concentrations (MPC) recommended by the International Commission on Radiological Protection (ICRP), or the daily intake guides recommended by the Federal Radiation Council (FRC).

Sensitive instruments, which can detect traces of radioactive materials far below concentrations of hazard significance, are used to determine radioactivity in the environs. Plant-released radioactivity cannot be readily distinguished from weapons tests fallout, and both are included in the reported concentrations. Maximum and minimum values given are for individual samples collected during the report period.

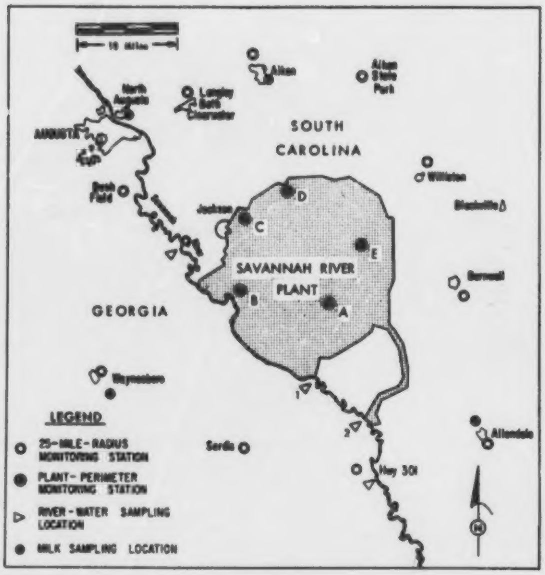
10 Miles
Aiken
Aiken State Park
North Augusta
Langley Bath Clearwater
AUGUSTA
SOUTH CAROLINA
Williston
Blackville
Bush Field
Jackson
D
C
E
SAVANNAH RIVER PLANT
B
A
Barnwell
GEORGIA
Waynesboro
1
2
Allendale
Sardis
Hwy 301
LEGEND
25-MILE-RADIUS MONITORING STATION
PLANT-PERIMETER MONITORING STATION
RIVER-WATER SAMPLING LOCATION
MILK SAMPLING LOCATION
N

Figure 2. Environmental sampling locations, Savannah River Plant

Atmospheric monitoring

Concentrations of radioactive materials in the atmosphere were measured by biweekly analyses of air filters collected at five monitoring stations near the plant perimeter and 10 stations around a circle of about 25 miles radius from the center of the plant (figure 2). Deposition rates of radioactive material at each station were also determined by monthly analyses of rainwater ion exchange columns (fallout collectors). The monitoring stations are spaced so that a significant release of airborne radioactivity by SRP would be detected regardless of the prevailing wind. All stations operate continuously. Four additional air monitoring stations at Savannah and Macon, Ga., and at Columbia and Greenville, S. C., are so distant from SRP that the effect of SRP operations is negligible; they are reference points for determining background radioactivity levels (figure 3). This system permits comprehensive surveillance of atmospheric radioactivity and also makes it possible to differentiate between weapons test fallout and SRP releases.

The small amount of filterable beta radioactivity released to the atmosphere, primarily from the fuel separations areas, was obscured by fallout from nuclear weapons tests. The influence of the weapons tests which resumed in September 1961 is shown in figure 4. The rise in early 1964 was the result of the anticipated spring increase in the mixing of stratospheric debris into the troposphere. The average beta radioactivity concentration in air decreased from 0.19 to 0.09 pCi/m^3 during July–December 1968.

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[3] Summarized from "Effect of the Savannah River Plant on Environmental Radioactivity, Semiannual Report, July–December 1968" (DPST 69-30-1)

Radioactivity in air, determined from filter analyses, is shown in table 3. The July–December 1968 concentrations of filterable beta radioactivity (0.09 pCi/m^3) and alpha radioactivity (0.0007 pCi/m^3) in air were 0.09 and 1.0 percent of the respective MPCs. Tritium oxide concentrations in air, at the plant perimeter and at the 25-mile stations, did not exceed 0.2 percent of the MPC.

Deposition of fallout during July–December 1968 totaled 7 nCi/m^2 at the plant perimeter locations and 5 nCi/m^2 at 25-mile radius locations; comparable values for the first half of 1968 were 7.3 and 7.7 nCi/m^2 (the 21 and 17 nCi/m^2 reported previously for the January–June 1968 period, included naturally occurring Beryllium-7). Deposition at each sampling location is presented in table 4.

Algae and fish in Savannah River

Fish, predominantly bream, and indigenous algae, primarily green (*Vaucheria*) and blue-green (*Phormidium*), were collected weekly upstream from, adjacent to and downstream from the Savannah River Plant. Determination of radionuclides in algae is important because algae concentrate certain radionuclides and also because of the role of algae in the food chain of aquatic organisms. Beta-particle concentrations in algae and fish adjacent to and downstream from SRP indicate some minor contribution by SRP. Although measurably higher than similar material collected at the control station 3 miles upstream from SRP, the slight increase is of no biological significance.

Specific radionuclide analyses were made on algae and fish collected from the Savannah River. Radiocesium and radiostrontium were found consistently in river algae; whereas cerium-141, -144, chromium-51, zirconium-niobium-95, manganese-54, zinc-65, and cobalt-60 were detected less frequently. Also, radiostrontium (maximum, 15 pCi/g, wet weight) was detected in bone tissue of river fish, and radiocesium (maximum 5 pCi/g, wet weight) was detected in the flesh tissue. The maximum concentrations of phosphorus-32 detected in bone of river fish was 56 pCi/g; and the maximum phosphorus-32 in flesh of river fish was 19 pCi/g.

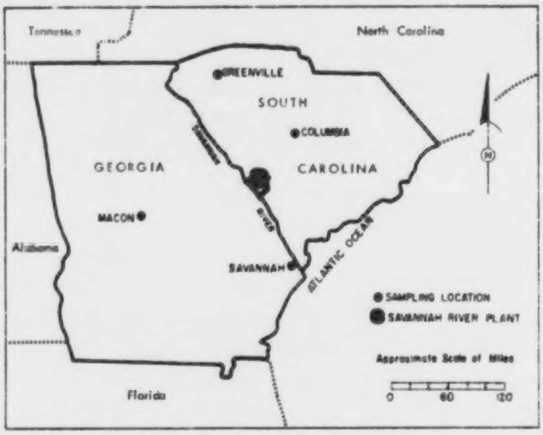

Figure 3. Distant air monitoring stations, Savannah River Plant

Water monitoring

The plant site is drained by five streams that flow several miles through the reservation before reaching the river (figure 5). In January 1965, the Beaufort–Jasper Water Authority began operation of a new treatment facility to furnish drinking water, partially supplied from the Savannah River, to most of Beaufort County, South Carolina. Water is supplied through a new canal from the river at a location about 90 miles below the SRP. The city of Savannah also supplements its domestic well water supply with river water during periods of peak demand.

Communities near the plant get domestic water from deep wells or surface streams. Public water supplies from 14 surrounding towns were collected and analyzed in October. There was no evidence that SRP contributed radioactivity to drinking water supplies; concentrations of alpha radioactivity (0.5 pCi/liter) and beta radioactivity (4 pCi/liter) were essentially the same as those observed before plant startup.

River water, analyzed weekly, was sampled continuously at four locations, as shown in figure

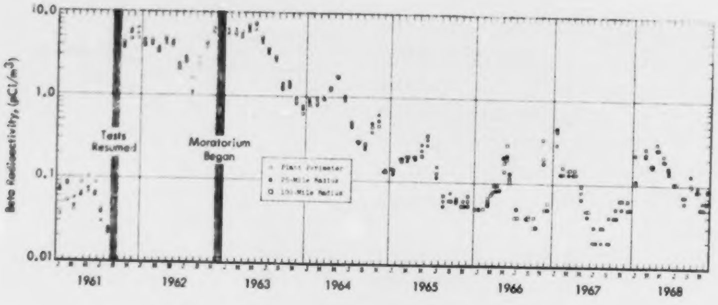

Figure 4. Influence of weapons tests

5. Average concentrations of specific radionuclides found in river water during July–December 1968 appear in table 5.

Tritium, sulfur–35, and trace amounts of cesium–137, strontium–89, and strontium–90, released mainly from reactor areas, were the radionuclides of SRP origin detectable in river water at the downstream location. Strontium–90 and tritium from worldwide fallout were also detected in river water upstream from the Savannah plant.

Tritium, a beta-particle emitter and the most abundant radionuclide released to the river, is produced by neutron irradiation of heavy-water moderator in the reactors. Sulfur–35, also a beta-particle emitter and the second most abundant radionuclide released to the river, is produced by neutron irradiation of stable sulfur (a component of the ion exchange resin used in the moderator-purification system in reactor areas). The tritium and sulfur–35 concentrations in river water averaged 0.30 and 0.03 percent of the MPC, respectively.

Vegetation

Radioactive contamination of growing plants may result from deposition on foliar surfaces or absorption of radioactive materials from the soil.

Grass samples were collected at seven locations along the plant perimeter and at seven other locations along a 25-mile radius route. (These are not designated on figure 2). Samples from each quadrant of the plant site and of the surrounding area were composited for monthly analysis. Radionuclides in grass samples were from fallout. Alpha-particle emitters averaged 0.1 pCi/g at the plant perimeter and 25-mile radius locations as compared to 0.2 pCi/g during the first half of 1968; gamma-ray emitters averaged 7.4 and 8.6 pCi/g, respectively, as compared to 21 and 31 pCi/g for the first half of 1968.

Milk

Milk was sampled at three dairies within a 25-mile radius of the Savannah River Plant, as shown in figure 2. Samples which were collected biweekly were analyzed for tritium and radioiodine. Strontium–90 determinations were made quarterly. Milk produced in the area and sold by major distributors was also analyzed for these radionuclides. Results from analyzing milk for radioactivity during July–December 1968 are shown in table 6.

Average concentrations of the radionuclides in milk (10 pCi/liter for strontium–90 and <5 pCi/liter for iodine–131, compared to 17 and <5 pCi/liter, respectively, during the first half of 1968) were consistent with values reported by the U.S. Public Health Service for most sections of the United States. Tritium in local milk, when present, is assumed to be associated with plant operations. The average tritium level was less than the sensitivity of the analysis, which allows detection of a concentration of 3,000 pCi/liter (<0.1 percent of the MPC for water).

Food

Farm produce representing four food categories (grain, fruit, poultry, and leafy vegetables) were collected at 14 localities in the six counties surrounding SRP (not shown on maps) during the summer and fall of 1968. Sixty-two samples were analyzed by gamma spectrometry for cerium-141, -144, iodine-131, ruthenium-103, -106, cesium-137, zirconium-niobium-95, and magnanese-54. Radiochemical analyses were used for strontium-90 and alpha-particle emitters (uranium and plutonium). With the exception of grains, all foods were prepared for analysis in a manner similar to that used to prepare them for eating. Peelings, seeds, and other nonedible parts were removed. Wheat, containing the whole grains only, and oats, containing both grains and husks, were processed unwashed. Concentrations in some samples were too low for reliable measurement, and only results above the detection limit of the analyses are included.

SRP contributions to the levels of radioactivity in foods were so low in 1968 as to be indistinguishable from fallout. With the exception of cesium-137 and strontium-90, all radionuclides in food were near or below levels of detection. The amounts of strontium-90 and cesium-137 were about the same as in the 1967 samples with respective peak values again in collards (0.41 pCi/g) and grains (0.09 pCi/g).

Environmental gamma radiation levels

Monthly measurements of environmental gamma radiation were made with thermoluminescent dosimeters. The July-December 1968 data (shown in table 7), are characteristic of measurements observed at individual stations for the past several years.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January-June 1968	January 1969

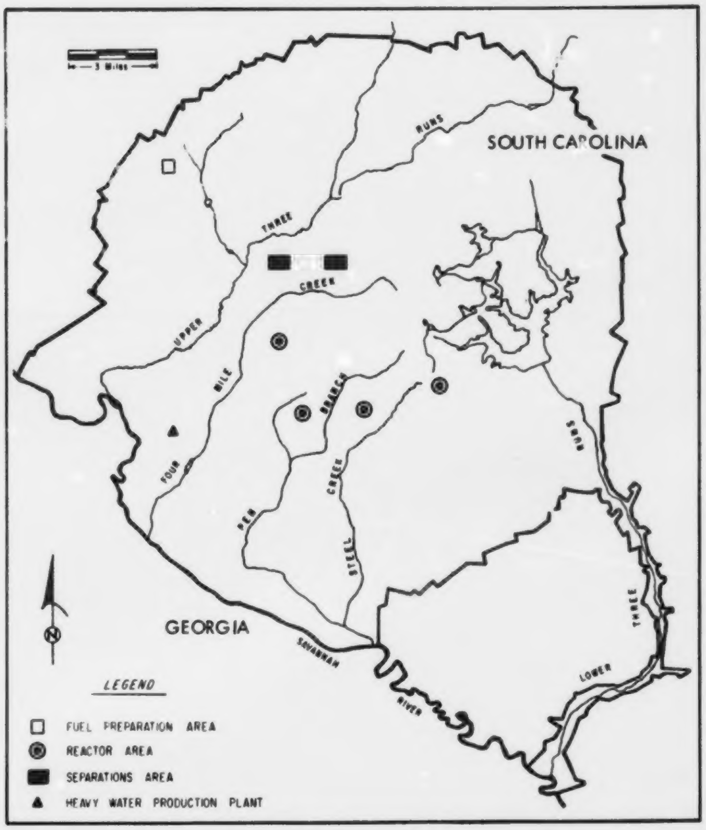
3 Miles
SOUTH CAROLINA
GEORGIA
UPPER THREE RUNS
CREEK
FOUR MILE
PEN BRANCH
STEEL CREEK
LOWER THREE RUNS
SAVANNAH RIVER
N
LEGEND
☐ FUEL PREPARATION AREA
◉ REACTOR AREA
■ SEPARATIONS AREA
▲ HEAVY WATER PRODUCTION PLANT

Figure 5. SRP production and effluent streams

Table 3. Radioactivity in air, Savannah River Plant, July–December 1968

Filter analysis	Average concentrations (pCi/m³)																
	Plant perimeter locations						25-mile radius locations										
	A	B	C	D	E	Average	Aiken airport	Aiken State Park	Allendale	Barnwell	Bush Field	Langley	Sardis	Waynesboro	Williston	Highway 301	Average
Alpha particle emitters[a] multiply by 10^{-3})	1.1	0.9	1.1	1.1	0.8		1.9	1.2	1.2	1.0	1.7	1.0	0.9	1.0	1.3	1.5	
Maximum	1.1	.9	1.0	1.0	.8		1.9	1.2	1.2	1.0	1.7	1.0	.9	1.0	1.3	1.5	
Minimum	ND	ND	.3	ND	ND		.4	.3	ND	.3	.4	ND	.3	ND	.3	ND	
Average	.6	.5	.7	.6	.5	0.6	.8	.6	.6	.6	.9	.6	.6	.6	.6	.6	0.6
Nonvolatile beta-particle emitters[b]																	
Maximum	.15	.16	.15	.17	.15		.21	.18	.15	.14	.15	.17	.17	.15	.22	.14	
Minimum	.05	.01	.05	.04	.02		.04	.04	.04	.03	.03	ND	.03	.04	.02	.02	
Average	.09	.08	.09	.09	.08	.09	.09	.08	.08	.08	.12	.08	.09	.09	.10	.08	.09
	Composite sample						Composite sample										
Specific radionuclides (averages)																	
Strontium–89, 90	0.002						0.003										
Cesium–137	.01						.005										
Cerium–141, –144	.008						.02										
Ruthenium–103, –106	.01						.01										
Zirconium-niobium-95	.04						.02										
Beryllium–7	.13						.11										

[a] Sensitivity of analysis −0.3 fCi/m³; ICRP Maximum Permissible Concentration: 0.07 pCi/m³.
[b] Sensitivity of analysis −0.006 pCi/m³; ICRP Maximum Permissible Concentration: 100 pCi/m³.
ND, nondetectable, less than sensitivity of analysis.

Table 4. Total fallout deposited, Savannah River Plant, July–December 1968

Radionuclide	Deposition (nCi/m²)																
	Plant perimeter locations						25-mile-radius locations										
	A	B	C	D	E	Average	Aiken Airport	Aiken State Park	Allendale	Barnwell	Bush Field	Langley	Sardis	Waynesboro	Williston	Highway 301	Average
Alpha[a]	1.7	3.9	4.6	5.6	2.3	3.6	1.9	2.7	3.0	1.1	2.1	2.7	2.1	3.2	1.9	3.7	2.4
Strontium–89	.5	.6	.5	.7	.5	.6	.6	.03	.3	.3	.5	.3	.3	.1	.2	.04	.3
Strontium–90	.4	.3	.5	.4	.5	.4	.4	.4	.3	.3	.3	.5	.3	.4	.4	.3	.4
Cesium–137	.7	.8	.7	.7	.8	.7	.7	.6	.4	.3	.7	.8	.9	.8	.5	.5	.6
Cerium–141, –144	3.1	2.9	5.3	4.1	3.8	3.9	3.6	2.1	2.5	2.9	3.0	4.1	3.0	3.0	2.3	2.4	2.9
Zirconium–niobium–95	1.5	.7	1.6	1.5	1.5	1.4	1.3	1.0	.7	1.0	1.5	1.9	1.4	1.4	1.2	1.0	1.2
Beryllium–7	10.4	8.4	16.0	16.5	14.4	13.1	12.1	6.7	6.4	4.9	8.7	7.7	8.0	8.0	6.1	7.4	7.7

[a] Multiply by 10^{-3}.

Table 5. Average concentration of radionuclides in Savannah River water July–December 1968

Radionuclides	Concentration (pCi/liter)			
	Sensitivity of analysis	Control (3 miles upstream from plant)	Highway 301 (10 miles downstream from plant)	Percent MPC at Highway 301
Tritium	600	740	9,200	0.30
Ruthenium–103, –106	3.2	ND	ND	< .03
Cerium–141, –144	2.5	ND	ND	< .02
Cesium–134, –137	.6	ND	1.4	.007
Neptunium–239	2.2	ND	ND	< .002
Barium–lanthanum–140	1.6	ND	ND	< .01
Zirconium–niobium–95	.5	ND	ND	< .001
Chromium–51	4.3	ND	ND	< .001
Strontium–89	.3	ND	2.6	.09
Iodine–131	.5	ND	ND	< .16
Strontium–90	.01	.6	1.0	.33
Cobalt–60	1.4	ND	ND	< .005
Zinc–54	1.1	ND	ND	< .001
Manganese–54	.4	ND	ND	< .0004
Sulfur–35	10.0	ND	20	< .03

ND, nondetectable, less than sensitivity of analysis.

Table 6. Radioactivity in milk from local dairies, Savannah River Plant July–December 1968

Distributing points	Concentration (pCi/liter)							
	Tritium[a]			Strontium–90[b]		Iodine–131[c]		
	Maximum	Minimum	Average	Sept.	Dec.	Maximum	Minimum	Average
Aiken	ND	ND	ND	7	11	ND	ND	ND
North Augusta	6,000	ND	ND	14	12	ND	ND	ND
Waynesboro	ND	ND	ND	NS	7	ND	ND	ND
Major distributors[d]	ND	ND	ND	10	10	ND	ND	ND

[a] Sensitivity of analysis—3,000 pCi/liter.
[b] Sensitivity of analysis—1.0 pCi/liter.
[c] Sensitivity of analysis—5.0 pCi/liter.
[d] Milk produced in local dairies, but sold by major distributors.
ND, nondetectable, less than sensitivity of analysis.
NS, no sample.

Table 7. Environmental gamma radiation, Savannah River Plant, July–December 1968

Filter Analysis	Exposure (mR/day)																
	Plant perimeter locations						25-mile radius locations										
	A	B	C	D	E	Average	Aiken Airport	Aiken State	Allendale	Barnwell	Bush Field	Langley	Sardis	Waynesboro	Williston	Hwy 301	Average
Maximum	0.29	0.35	0.40	0.35	0.50		0.36	0.36	0.37	0.36	0.38	0.40	0.36	0.34	0.39	0.54	
Minimum	.12	.10	.10	.06	.14		.07	.20	.14	.17	.17	.16	.14	.11	.16	.20	
Average	.27	.25	.24	.21	.32	0.26	.24	.24	.27	.25	.24	.26	.23	.20	.30	.26	0.25

Reported Nuclear Detonations, October 1969

(Includes seismic signals)

The Atomic Energy Commission conducted an underground nuclear calibration test at Amchitka Island, Alaska, at 12:06 p.m. Bering Daylight Time, October 2, 1969. The calibration test, called MILROW, employed a device of known explosive power—the equivalent of about one megaton of TNT—and registered 6.5 on the Richter scale as previously predicted by AEC. MILROW was detonated 4,000 feet under the surface of Amchita Island. Also as forecast, there were no damaging earthquakes.

AEC's preliminary report, issued October 22, 1969, stated that only minor effects had been observed following the detonation. "Temporary buildings at ground zero show external evidence of damage but still are standing. Careful examination of our extensive instrumentation indicates no radioactivity escaped either to the atmosphere or to the sea."

No unusual water wave activity was reported at any tide stations other than a very slight ripple not exceeding 2 inches, which was noted near the island. Preliminary observations made within 0.6 miles from ground zero have not indicated any apparent ecological effects. Sea otters held in a pen on the shore about 4,500 feet from surface ground zero (SGZ) appeared normal and all ate food offered 4 hours after the shot. These otters, along with others in floating pens located at greater distance from SGZ, will be under observation for several days in search of possible delayed effects, after which they will be released into their natural habitat.

Data from MILROW will be extensively analyzed and the knowledge gained from these analyses will be carefully studied before any determination is made regarding further testing on the island.

On October 8, 1969, the Atomic Energy Commission announced that it has conducted an underground nuclear test in the intermediate yield range (200 to 1 megaton TNT equivalent) at its Nevada Test Site.

The Atomic Energy Commission conducted three underground nuclear tests at its Nevada Test Site on October 29, 1969. The first test was in the low yield range, equal to less than 20 kilotons of TNT equivalent. The second and third tests conducted at 3:00 and 5:02 p.m., EST, were in the low-intermediate yield range (20 to 200 kilotons TNT equivalent). The tests were conducted safely, although the second (3 p.m.) test resulted in a minor release of radioactivity.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

ENVIRONMENTAL SURVEY OF URANIUM MILL TAILINGS PILE, TUBA CITY, ARIZONA. *Southwestern Radiological Health Laboratory, Bureau of Radiological Health. Radiological Health Data and Reports, Vol. 10, November 1969*, pp. 475–488.

At the request of the Navajo Tribal Council, an environmental radiological survey was conducted on the El Paso Natural Gas Company uranium tailings pile, Tuba City, Arizona, in May 1967. The purpose of the survey was to evaluate potential radiation hazards and to recommend methods of control. The survey included evaluation of external gamma radiation, airborne radioactivity, and waterborne radioactivity.

The results indicate that the external radiation levels on the tailings area exceed recommended exposure limits for individuals in the general population. Wind carriage of the tailings in an easterly direction from the pile has resulted in elevated radiation levels outside the controlled area.

On the basis of these data it was recommended that the mill tailings be properly stabilized against wind erosion or periodic monitoring would be necessary. In May 1968, the pile was regraded and stabilized against wind erosion using a chemical binder. Because of the external radiation levels on the tailings area, this area was not released for public use. It was fenced and posted as a radiation area. The housing area was released to the Navajo Tribe and is presently occupied.

KEYWORDS: Air, Arizona, environmental surveillance, external radiation, uranium daughter products, uranium mill tailings, water.

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 10, Number 12, December 1969

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Bureau of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Bureau of Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

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RADIOLOGICAL HEALTH DATA AND REPORTS

Published under the direction of

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Offsite Radiological Surveillance for Project Gasbuggy June 1967-July 1968

John R. McBride and *Dixon Hill*[1]

Project Gasbuggy, an experiment to stimulate gas recovery by nuclear means, was conducted on December 10, 1967, as part of the Atomic Energy Commission's (AEC) Plowshare Program. The Public Health Service by Memorandum of Understanding with the AEC is responsible for a comprehensive offsite radiological safety program. The data obtained during this program have documented that no radioactivity was introduced into the environment as a result of the Project Gasbuggy detonation. Surveillance of the El Paso natural gas producing wells near the Gasbuggy experiment was conducted to insure that gas contaminated with radioactivity was not present.

On Sunday, December 10, 1967, at 12:30:00 mountain standard time (m.s.t.), at a location 55 air miles east of Farmington, N. Mex., a 26-kiloton thermonuclear explosive was detonated 4,240 feet below the surface of the Carson National Forest (figures 1 and 3). The event, Project Gasbuggy, was the first joint government-industry experiment in the U.S. Atomic Energy Commission's (AEC) Plowshare Program. The joint sponsors, in addition to the AEC, were the U.S. Department of the Interior (Bureau of Mines) and the El Paso Natural Gas Company.

The main objective of the experiment was to determine if nuclear explosions can increase the production rate and ultimate recovery of natural gas from low permeability gas formations. Some flow tests, as well as gas quality analyses, have been made of the Project Gasbuggy well by the project participants; however, until more extensive flow tests are made in 1969, conclusive information will not be available as to the degree of success of the experiment.

Factors affecting the safety of the project included: the depth of emplacement of the device, the proximity of an aquifer to the detonation, and the location of gas production wells with respect to ground zero. The device was placed at a depth of 4,240 feet in the Lewis Shale formation in the San Juan Basin. This depth is about 40 feet below the bottom of the gasbearing Pictured Cliffs formation (figure 2). At this depth, the device was considered to be overburied by safety standards in use at the Nevada Test Site. (A 26 kt device would be considered safely emplaced at NTS at a depth of approximately 1,200 feet.) The lowest water bearing formation is the Ojo Alamo sandstone which is located from 3,475 to 3,650 feet below the surface at the site. The nearest aquifer, therefore, is approximately 590 feet above the shot point. The site chosen for the project is on land leased by El Paso Natural Gas Company. The only wells in the area belong to them and the closest production well is 3,400 feet from ground zero. As a precaution, all producing wells within approximately a 5-mile radius of ground zero were physically separated from the gas-transmission system. In addition the AEC hypothesized all possible failure modes which could release radioactivity into the atmosphere, into ground water, or into the natural gas production system. Although these failure modes were considered highly unlikely, the AEC authorized a comprehensive radiological safety program for Project Gasbuggy.

---

[1] Mr. John R. McBride is deputy director and Mr. Dixon Hill was project engineer, Southwestern Radiological Health Laboratory, Las Vegas, Nev. During Project Gasbuggy, Mr. McBride was senior PHS official on the Project. Mr. Hill was project officer for Gasbuggy in charge of all offsite radiological safety activities.

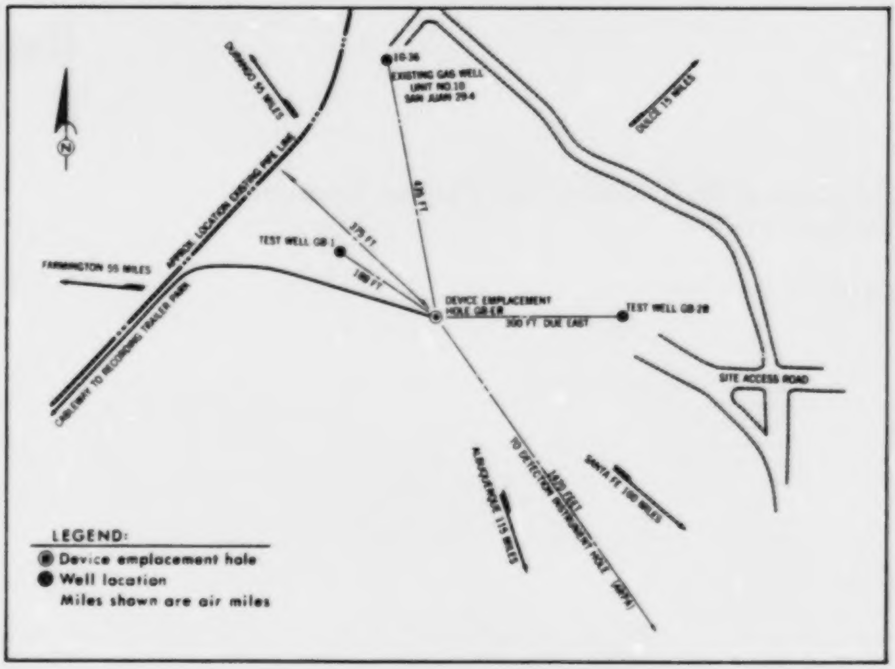
N
DURANGO 55 MILES
10-36
EXISTING GAS WELL
UNIT NO 10
SAN JUAN 29-4
DULCE 15 MILES
APPROX LOCATION EXISTING PIPE LINE
375 FT
TEST WELL GB-1
180 FT
FARMINGTON 55 MILES
DEVICE EMPLACEMENT
HOLE GB-ER
300 FT DUE EAST
TEST WELL GB-2R
SITE ACCESS ROAD
CABLEWAY TO RECORDING TRAILER PARK
TO DETECTION INSTRUMENT HOLE
ALBUQUERQUE 115 MILES
SANTA FE 100 MILES
LEGEND:
Device emplacement hole
Well location
Miles shown are air miles

Figure 1. Project Gasbuggy emplacement hole and well locations

Offsite radiological safety program

This article summarizes the offsite radiological safety program for Project Gasbuggy as conducted by the Southwestern Radiological Health Laboratory (SWRHL) of the Bureau of Radiological Health. In accordance with a Memorandum of Understanding between the AEC and the Public Health Service, the SWRHL is responsible for conducting offsite radiological safety programs for all U. S. nuclear tests.

A surveillance program was established by SWRHL to collect and analyze environmental samples before and after the nuclear detonation in order to document any possible release of radioactivity to the offsite area and to be prepared to handle emergency procedures to insure protection of the public health in case an unforeseen accident occurred. Samples provided data on air, milk, water, natural gas, and external radiation levels in the area surrounding the site.

The offsite surveillance program was divided into three periods:

1. The preshot preparations—June 1, 1967, to detonation (1230 m.s.t. December 10, 1967);
2. The post-shot period, including the redrill of the emplacement hole (GB-ER)—December 10, 1967, to January 19, 1968;
3. The redrill of the Gasbuggy-2 (GB-2R, one of the two exploratory wells drilled before the emplacement hole) and subsequent natural gas flaring operations from GB-ER and GB-2R—June 13 to July 22, 1968.

Environmental samples were collected preshot to establish background radioactivity levels. Following the completion of the post-shot period and again after the GB-2R redrill period, samples were collected to form a comparison with the background data.

The SWRHL preshot preparations in the Project Gasbuggy area began in June 1967. During the summer of 1967, a census was taken of all people and milk cows within 100 miles of the Gasbuggy site; in addition, all mining and tunneling operations within 50 miles were located.

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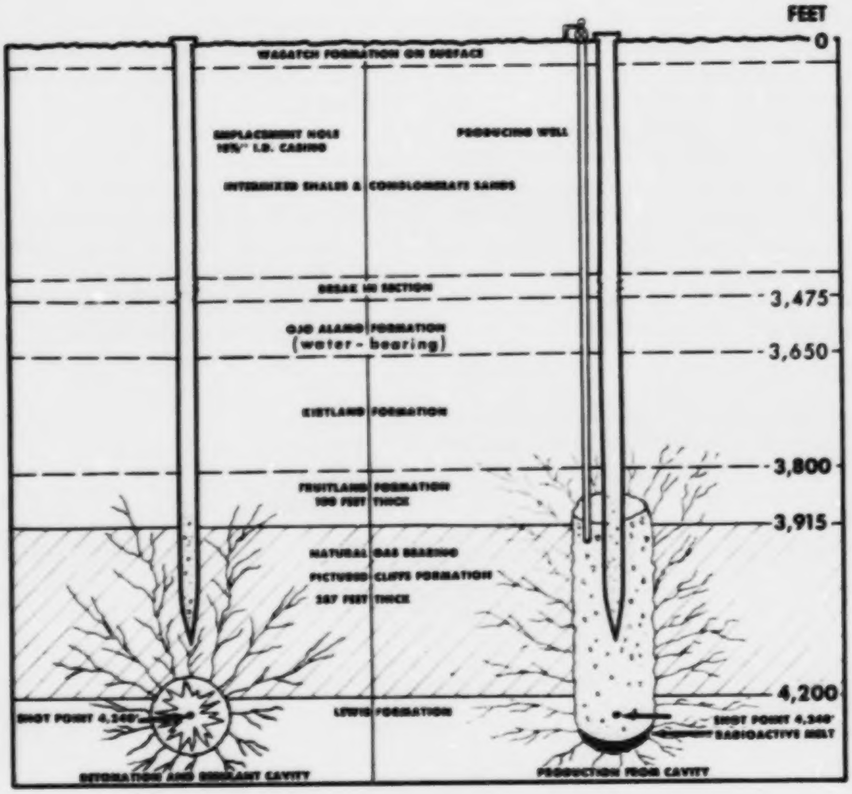
FEET
0
WASATCH FORMATION ON SURFACE
EMPLACEMENT HOLE
10¾" I.D. CASING
PRODUCING WELL
INTERMIXED SHALES & CONGLOMERATE SANDS
BREAK IN SECTION
3,475
OJO ALAMO FORMATION
(water - bearing)
3,650
KIRTLAND FORMATION
3,800
FRUITLAND FORMATION
100 FEET THICK
3,915
NATURAL GAS BEARING
PICTURED CLIFFS FORMATION
287 FEET THICK
4,200
LEWIS FORMATION
SHOT POINT 4,240'
SHOT POINT 4,240'
RADIOACTIVE MELT
DETONATION AND RESULTANT CAVITY
PRODUCTION FROM CAVITY

DATA:

Cavity diameter 160 feet
Chimney diameter 160 feet
Chimney height 350 feet
Total lateral fracturing (diameter) 850 feet
Total vertical fracturing (top to bottom) 430 feet

Figure 2. Project Gasbuggy predicted underground effects

As the census information was collected, personnel distributed printed information explaining the nature of the experiment and answered questions regarding their activities. The Community Relations Program was intensified during later periods when the SWRHL project officer and State health department officials visited local officials in surrounding communities. The initial environmental sampling was begun in August 1967. The dosimetry program began in October 1967. Medical and veterinarian activities began during the preshot period when the respective officers made visits to various State and local officials; these activities continued throughout the drill-back of GB-ER. Approximately 30 people from the SWRHL and the health departments of New Mexico and Colorado were assigned to the SWRHL Gasbuggy surveillance program on December 1, 1967. A short training course was given to State personnel on procedures to be used and all personnel were oriented to the area around the site.

At shot time, SWRHL had 33 people on station, including monitoring teams in two aircraft circling the site. The number of people was reduced in mid-December to five who remained throughout the redrill of GB-ER.

The GB-2R redrill operations began in mid-June 1968, and were completed by mid-July 1968. They included the redrill of GB-2R and flow testing (flaring) of natural gas from the GB-ER well for 15 days. The project officer was onsite for these operations. Staff previously assigned to the project were on standby at SWRHL in the event additional field personnel were needed.

Air surveillance

The Project Gasbuggy Air Surveillance Network collected daily samples preshot and during the post-shot period at 35 locations surrounding the Gasbuggy site. Six of these stations were part of the SWRHL Air Surveillance Network (ASN) and two were activated ASN standby stations. The remaining 27 stations were established specifically for the project. The Gasbuggy network is shown in figure 3.

Air sampling stations were equipped with Gelman Tempest air samplers using a Gast Model-1550 positive displacement pump. The filter system used a 4-inch diameter Whatman-541 filter in series with a 4-inch MSA[1] activated charcoal cartridge.

The Gasbuggy Surveillance Network station began operations on November 27, 1967 and continued through December 13, 1967. The nine sta-

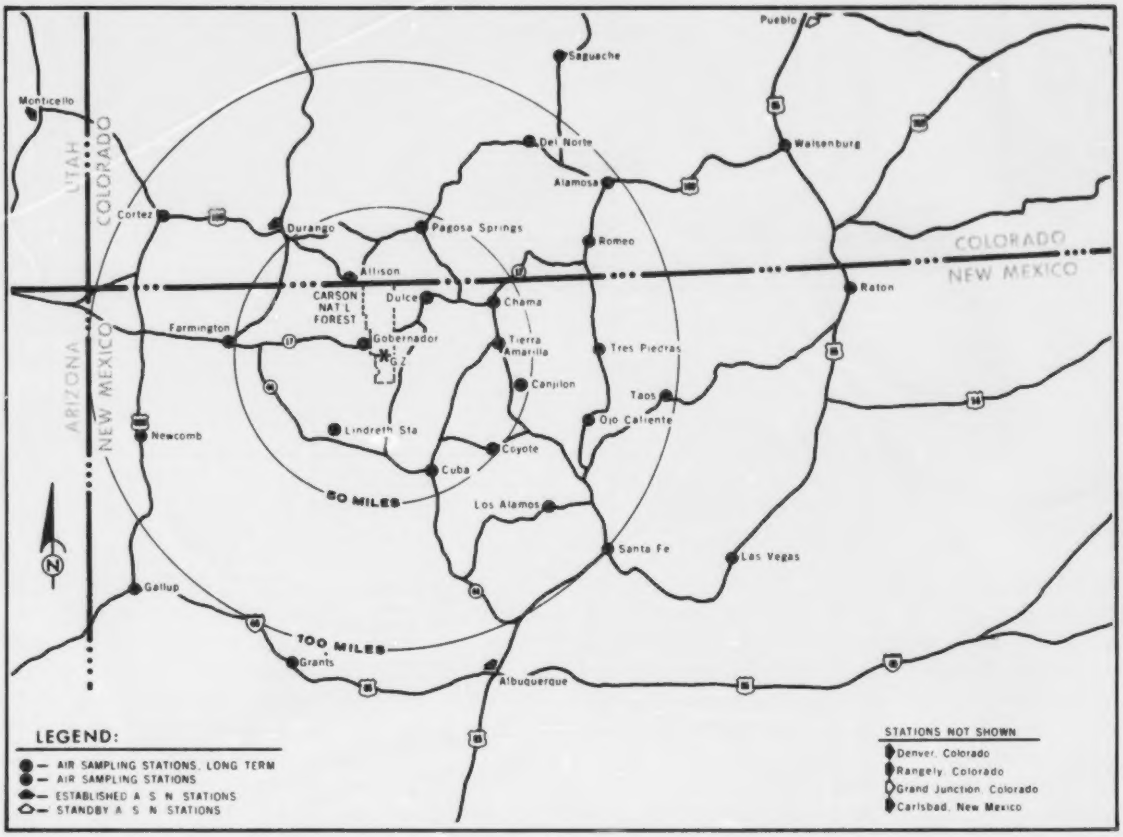
Pueblo
Saguache
Monticello
UTAH
COLORADO
Del Norte
Walsenburg
Alamosa
Cortez
Durango
Pagosa Springs
Romeo
COLORADO
NEW MEXICO
Allison
Raton
CARSON NAT'L FOREST
Dulce
Chama
Farmington
Gobernador
Tierra Amarilla
Tres Piedras
G.Z.
Canjilon
Taos
ARIZONA
NEW MEXICO
Ojo Caliente
Newcomb
Lindreth Sta
Coyote
Cuba
50 MILES
Los Alamos
N
Santa Fe
Las Vegas
Gallup
100 MILES
Grants
Albuquerque
LEGEND:
● — AIR SAMPLING STATIONS, LONG TERM
● — AIR SAMPLING STATIONS
— ESTABLISHED A. S. N. STATIONS
— STANDBY A. S. N. STATIONS
STATIONS NOT SHOWN
Denver, Colorado
Rangely, Colorado
Grand Junction, Colorado
Carlsbad, New Mexico

Figure 3. Project Gasbuggy air surveillance network

tions nearest the site were operated throughout the GB-ER drill-back period until January 19, 1968. A total of 1,120 sets of samples was collected. In mid-April 1968, 16 of the 27 special stations were discontinued, leaving 11 on standby. These stations were operated from June 30 to July 18, 1968. A total of 200 sets of samples was collected during this period.

---

[1] MSA—Mine Safety Appliance, part 46727 charcoal cartridge. The cartridge is an organic-vapor-type cartridge containing stable iodine to improve the organic iodide retention capability.

All filters and charcoal cartridges were mailed directly to SWRHL for analysis. The filters were analyzed for beta radioactivity upon arrival at the laboratory and again on the fifth and twelfth day after collection. If the initial beta-particle count indicated a radioactivity concentration of more than 1 picocurie per cubic meter, or if the 5-day count was more than 150 counts per minute above background, the filter was analyzed by gamma-ray spectroscopy. The charcoal cartridge was gross gamma-ray counted upon arrival and, if the count was greater than 500 counts per minute, the filter and cartridge were analyzed by gamma-ray spectroscopy. These control limits were based on normal background concentrations.

The air sampling results for each of the three periods are summarized in table 1. The post-shot period is further divided into two periods since levels of radioactivity in air were generally higher across the United States during the last 5 days of December 1967.[3] Examples of this increase at scattered stations west of the Mississippi River are given in table 1 (footnote c).

Milk surveillance

Milk sampling coverage was provided by the Gasbuggy Milk Surveillance Network during the preshot and operational periods. Twenty-two stations were sampled; 13 represented family milk cows and nine were Grade-A dairies. The station locations are shown in figure 4.

Samples were collected at each location during the following periods: July 30 to August 1, 1967; September 4–7, 1967; October 20–25, 1967; and January 19–20, 1968. In addition, five samples were collected on December 14, 1967. A total of 75 1-gallon samples was collected and shipped to SWRHL for analysis.

The analysis of the 1-gallon milk samples consisted of two procedures: gamma-ray counting and radiochemical analysis for strontium. Upon arrival at SWRHL, 3½ liters of the sample were analyzed by gamma-ray spectroscopy for 40 minutes. The gamma-ray analysis information was proc-

---

[3] Additional information on increased levels can be found in reference 1.

Table 1. Summary of beta radioactivity in air[a]
Gasbuggy air surveillance network

Period[b]	Number of stations operating	Number of samples taken	Number of samples above detectable limits	Range (pCi/m³)		Average of samples above detectable limits (pCi/m³)	Average of all samples (pCi/m³)
				Minimum	Maximum		
Period 1—preshot: 11/27/67 to 12/9/67	35	404	80	0.1	1.3	0.2	[c]<0.1
Period 2—post-shot: 12/10/67 to 12/24/67	[d]35 or 12	240	27	.1	.3	.1	<.1
12/25/67 to 1/19/68	[e]12 or 25	371	336	.1	7.8	1.0	.9
Selected ASN stations:[f] 12/25/67 to 1/19/68	5	105	63	.1	9.5	.8	.5
Period 3—GB-2R redrill: 6/13/68 to 7/18/68	10	200	190	.1	1.0	.2	.2

[a] Gamma-ray analysis results, none of which showed radioactivity above background, are available from SWRHL.
[b] 1/19/68 to 6/13/68—all stations on standby.
[c] Detectable; limit: beta radioactivity—0.1 pCi/m³ based on 300 m³ and 2-minute-counting time.
[d] 12/10/67 to 12/13/67: 35 stations operated. 12/13/67 to 12/24/67: 12 stations operated.
[e] 1/12/67 to 1/11/68: 12 stations operated. 1/11/68 to 1/19/68: 25 stations operated.
[f] Selected ASN stations:

Station	Station no.
Minneapolis	65
Berkeley	40
Seattle	50
Phoenix	43
New Orleans	92

These scattered stations were selected to show that the increased radioactivity was widespread.

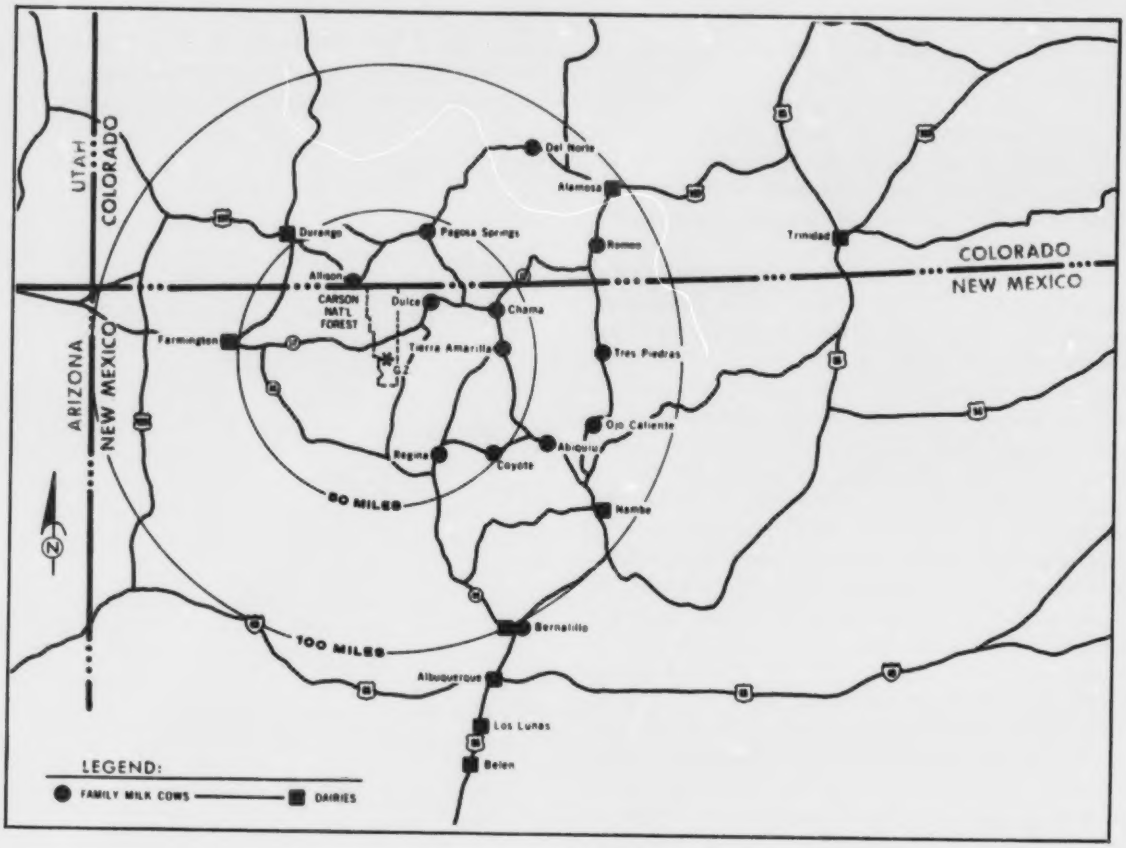
UTAH
COLORADO
ARIZONA
NEW MEXICO
COLORADO
NEW MEXICO
Del Norte
Alamosa
Durango
Pagosa Springs
Romeo
Trinidad
Allison
CARSON NAT'L FOREST
Dulce
Chama
Farmington
Tierra Amarilla
GZ
Tres Piedras
Ojo Caliente
Abiquiu
Regina
Coyote
50 MILES
Nambe
N
Bernalillo
100 MILES
Albuquerque
Los Lunas
Belen
LEGEND:
FAMILY MILK COWS
DAIRIES

Figure 4. Project Gasbuggy milk surveillance network

essed through a computer program which quantified the samples for iodine-131, cesium-137, barium-140, and lanthanum-140. After the computer program completed the results, the spectroscopic information was examined to ascertain that no other radionuclides were present. The strontium analysis consisted of passing 1 liter of the sample through an ion-exchange resin column which retained the strontium. The strontium, after being eluted from the column, was precipitated as a carbonate compound and was counted after weighing and again 1 week later. The strontium-89 and -90 concentrations were solved by simultaneous equations.

The milk sampling results for periods 1 and 2 are summarized in table 2. No milk samples were taken following the GB-2R redrill (period 3) since all radioiodines had decayed below significant levels.

Water surveillance

Water sampling coverage during the preshot and post-shot periods was provided by a network of 34 sampling stations, shown in figure 5. Fifteen of the sampling locations were within 20 miles of ground zero at open- and well-water sources, and 13 of the locations were the same as the family milk cow sampling stations. Six of the network locations were municipal water systems located within approximately 120 miles from ground zero.

Seventy-four 1-gallon samples were collected on the same schedule as milk samples prior to the GB-2R redrill. Seven samples were collected during and immediately following the GB-2R redrill. All samples were sent to SWRHL for analysis. Upon arrival at SWRHL, 3½ liters of the sample were analyzed by gamma-ray spectroscopy for

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Table 2. Summary of Gasbuggy milk analysis results, periods 1 and 2

Isotope	Number of samples analyzed	Number of samples above detectable limits[a]	Range (pCi/liter) Minimum	Range (pCi/liter) Maximum	Average of samples above detectable limit (pCi/liter)	Average of all samples (pCi/liter)
Preshot:						
Iodine-131	52	0	—	—	—	ND
Cesium-137	52	6	10	34	20	<10
Strontium-89	30	4	5	5	5	< 5
Strontium-90	30	29	3	18	6	6
Post-shot:						
Iodine-131	23	0	—	—	—	ND
Cesium-137	23	1	16	16	16	<10
Strontium-89	20	2	5	5	5	< 5
Strontium-90	20	18	2	8	5	4

[a] Detectable limits: Iodine-131—10 pCi/liter, based on 3,500-ml sample counted for 40 min.
Cesium-137—10 pCi/liter, based on 3,500-ml sample counted for 40 min.
Strontium-89—5 pCi/liter, based on 1-liter sample counted for 50 min.
Strontium-90—2 pCi/liter, based on 1-liter sample counted for 50 min.

ND, nondetectable.

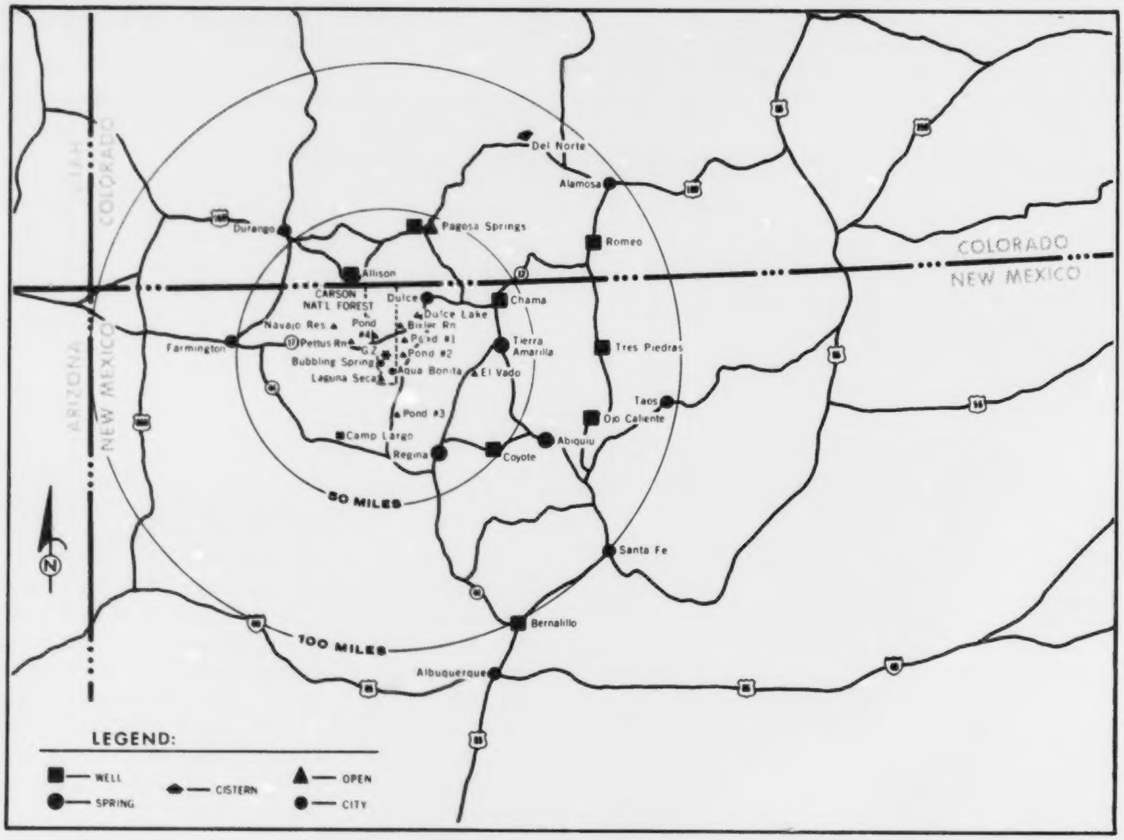
UTAH
COLORADO
ARIZONA
NEW MEXICO
COLORADO
NEW MEXICO
Del Norte
Alamosa
Durango
Pagosa Springs
Romeo
Allison
CARSON NAT'L FOREST
Dulce
Dulce Lake
Chama
Navajo Res
Pond #4
Bixler Rn
Pond #1
Pettus Rn
G.Z.
Pond #2
Farmington
Bubbling Spring
Aqua Bonita
El Vado
Laguna Seca
Tierra Amarilla
Tres Piedras
Taos
Pond #3
Ojo Caliente
Camp Largo
Abiquiu
Regina
Coyote
50 MILES
Santa Fe
N
Bernalillo
100 MILES
Albuquerque
LEGEND:
WELL
SPRING
CISTERN
OPEN
CITY

Figure 5. Project Gasbuggy water surveillance network

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40 minutes. This information was processed through a computer program which routinely calculates values for the following isotopes; cerium-praseodymium-144, barium-lanthanum-140, cesium-137, iodine-131, ruthenium-106, zirconium-niobium-95, manganese-54, and potassium-40.

If it had been determined that additional analysis for other radionuclides was necessary, a different set of isotopes could have been specified. However, none of the samples required additional analysis. After the gamma-ray analysis, 250 milliliters of the sample were evaporated and the residue counted for gross alpha and gross beta radioactivity. If the gross beta radioactivity had been greater than 100 pCi/liter at the time of counting, a strontium analysis would have been performed; if the gross alpha radioactivity had been greater than 30 pCi/liter, a radium-226 analysis would have been done. None of the samples required these additional analyses.

Water sampling results for periods 1 and 2 are summarized in table 3 and are given in table 4 for period 3. The samples taken during the preshot and post-shot periods (periods 1 and 2) were treated routinely as samples are from all Nevada Test Site operations. The samples taken following the GB-2R redrill (period 3), however, were taken specifically for tritium analysis; beta and alpha-particle counting was not done and all gamma-ray spectra were negligible.

Personnel surveillance

A network of thermoluminescent dosimeters (TLD's) and film badges was established surrounding the Gasbuggy site. The network consisted of 50 stations located at approximately 1 and ½-mile intervals along existing roads and highways, as shown in figure 6.

The background radiation level for the network area was established prior to the shot with stations consisting of three "dedosed" TLD's set out on October 17, 1967, and exchanged on November 15, 1967. They were exchanged again on December 8, 1967, 2 days before the shot, for three "dedosed" TLD's and two film badges.

The TLD's used were EG&G model TL-12 thermoluminescent CaF_2:Mn dosimeters (sensitivity range of 4 mR to 5,000 R) and the two film badges were DuPont type 545 film badges (sensitivity range of 30 mR to 3 R). Since there was no venting upon detonation, the TLD's and film badges set out December 8, 1967, were left in the field throughout the GB-ER redrill period which began immediately after the shot. The GB-ER redrill was completed on January 10, 1968, and the TLD's and film badges were returned to SWRHL for evaluation.

Table 3. Summary of Gasbuggy water analysis results[a]

Radioactivity	Number of samples counted	Number of samples above detectable limits[b]	Range (pCi/liter)		Average of samples above detectable limit (pCi/liter)	Average all samples (pCi/liter)
			Minimum	Maximum		
Preshot:						
Beta	76	52	2	40	8	5
Alpha	76	25	1	23	4	1
Post-shot:						
Beta	25	14	2	29	9	5
Alpha	25	7	1	16	3	1

[a] The concentrations determined by gamma-ray spectroscopy were negligible for all water samples.

[b] Detectable limits: beta radioactivity, 2 pCi/liter based on 250-ml sample counted for 50 minutes and alpha radioactivity, 1 pCi/liter based on 250-ml sample counted for 50 minutes.

Table 4. Gasbuggy water sampling results—period 3[a]

Date taken (1968)	Sample location	Tritium[b] (pCi/liter)	Gamma spectrum analysis
June 24	Pettus ranch		Negligible
June 27	Drilling water pond, Gasbuggy road and NM 17 (2 miles north of Pond #1)[c]		Negligible
July 16	Well and Pond #1	900	Negligible
	Pond #4	700	Negligible
	Drilling water pond	<400	Negligible
	Pond (2 miles southeast of Laguna Seca)[c]	800	Negligible
	Laguna Seca	<400	Negligible

[a] Period 3—GS-2 redrill and GB-ER and GB-2R flaring operations.

[b] Alpha and beta radioactivity counts were not made on these 7 samples. The tritium concentrations given are considered to be background.

[c] Not shown in figure 5.

An entirely different TLD network was established for the GB-2R redrill and GB-ER flaring

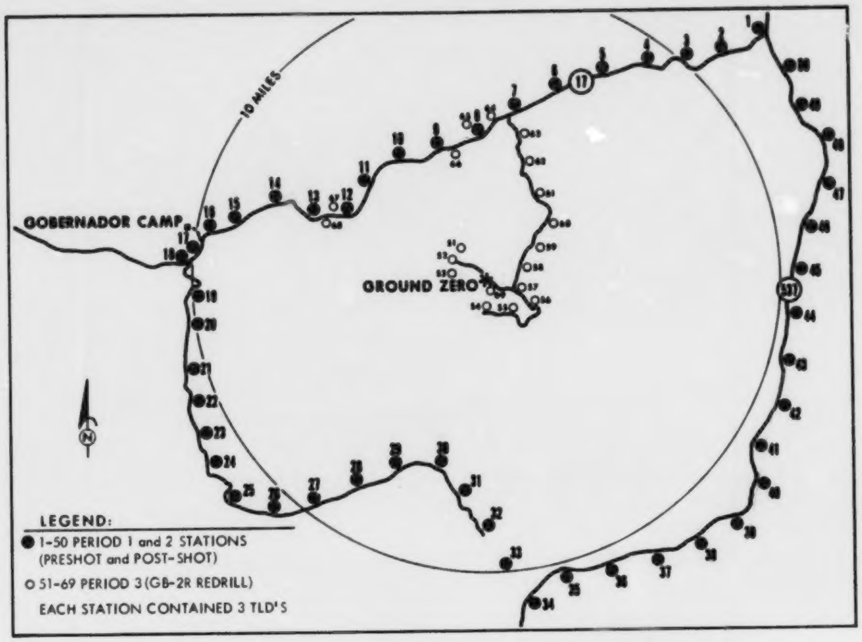
10 MILES
GOBERNADOR CAMP
GROUND ZERO
17
537
N
LEGEND:
● 1-50 PERIOD 1 and 2 STATIONS (PRESHOT and POST-SHOT)
○ 51-69 PERIOD 3 (GB-2R REDRILL)
EACH STATION CONTAINED 3 TLD'S

Figure 6. Project Gasbuggy thermoluminescent dosimeter stations

operation. TLD's were stationed around the site area at 19 locations ranging from 0.1 to 6 miles from ground zero. Three TLD's were placed at each location on June 27, 1968, and collected on July 16, 1968. The locations are shown in figure 6. The station locations were selected with regard to prominent wind direction during this period of the year. During daytime hours, the wind is primarily from the southwest. A stable condition generally exists during the nighttime hours when the air 'drains' downhill toward the northwest. A network was placed 1.3 miles northwest of ground zero, covering an arc from approximately 345 degrees to 180 degrees and a network crossing the valley through which the drainage winds pass.

The results of the TLD network during periods 1 and 2 are shown graphically in figure 7. The graph shows the average exposure recorded by the TLD stations located within 30-degree arcs. Table 5 gives the results of the less extensive TLD network used for period 3. Since the locations of most of the stations and length of exposure for the two networks were not the same, a direct comparison of the results should not be made.

Table 5. Gasbuggy thermoluminescent dosimeter results—period 3[a]

Station number[b]	Average daily exposure (mR)	Station number	Average daily exposure (mR)
51	0.28	62	0.14
52	.28	63	.25
53	.23	64	.27
54	.19	55	.28
55	.28	66	.27
56	.27	67	.28
57	.34	68	.25
58	.27	69	.27
59	.25		
60	.27	Controls—Farmington[c]	.27
61	.25		

[a] The actual period of exposure was June 27, 1968, to July 16, 1968.
[b] The station locations are given in figure 6.
[c] These dosimeters remained in Farmington to provide a comparative background for the period.

Natural gas surveillance

The PHS provided surveillance of radioactivity in the natural gas produced in the area surrounding the Gasbuggy site. This program consisted for an analysis for fresh fission products and natural radionuclides of the natural gas collected preshot and post-shot from all the wells and the gathering system located within 5 miles of ground zero.

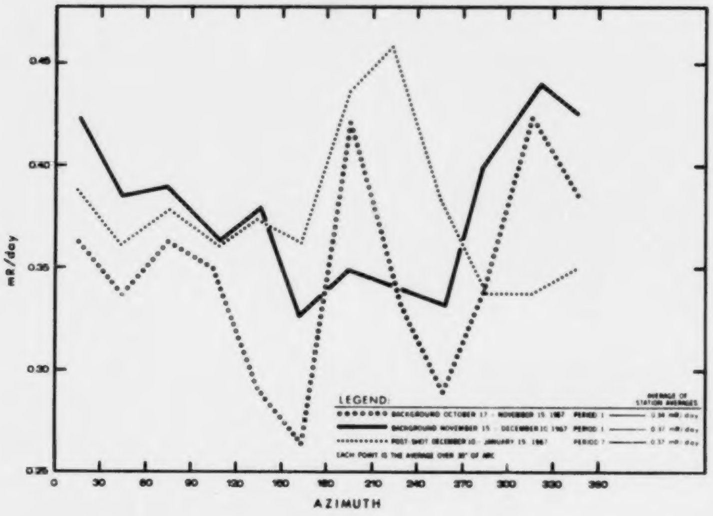

Figure 7. Project Gasbuggy thermoluminescent dosimeter station results periods 1 and 2

Fifteen samples were analyzed before the detonation to determine background radioactivity levels and 31 samples were analyzed after the detonation to check for increased levels of radiation. The results of these samples are given in table 6. In addition to the samples collected within 5 miles of ground zero, 12 samples were collected at more distant locations within the El Paso Natural Gas Company's system. The results of these samples are given in table 7. All samples were analyzed for radioistopes of xenon and krypton, and the radionuclides, radon-222, carbon-14, and tritium. The analysis of the gas samples showed no evidence of fresh fission products in any sample. Levels of radon-222 found in postshot samples were no higher than the background levels found in preshot samples.[4]

As of June 1, 1969, all producing gas wells within a 5-mile radius of ground zero are still physically cut from the El Paso Natural Gas Company's distribution system. Plans for sampling gas on a periodic basis from these producing wells when they are returned to the distribution system are presently being considered by the Atomic Energy Commission.

Summary and conclusions

The offsite radiological safety program conducted by the Southwestern Radiological Health Laboratory for the U.S. Atomic Energy Commission documented that no detectable radioactivity was introduced into the offsite environment as a result of the Project Gasbuggy detonation. In addition, the SWRHL was adequately prepared so that personnel could effectuate emergency procedures to insure protection of the public health had an unforeseen accident occurred.

Initial gas samples collected from the producing wells within approximately a 5-mile radius of ground zero as well as sampling of the El Paso Natural Gas Company's distribution system have showed, as of July 1968, that no migration of radionuclides into other wells has occurred.

Project Gasbuggy represented no hazard from radioactivity to the population in the vicinity of the detonation site nor has it resulted in the introduction of any device-related radioactivity into the existing natural gas distribution system of the El Paso Natural Gas Company.

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[4] For additional information on radon-222 values in gas produced in the San Juan Basin, see reference 2.

Table 6. Radon analyses from Gasbuggy preshot and post-shot natural gas sampling

Well	Formation[a]	Azimuth from ground zero	Distance from ground zero (miles)	Date collected	Radon-222 concentration[b] (pCi/ft³)
Preshot samples[c]:					
San Juan					
28-4 No. 26	MV	255°	5.15	9/19/67	1,068
	MV	255°	5.15	10/24/67	1,084
	MV	255°	5.15	11/14/67	1,034
29-4 No. 2	PC	274°	1.03	9/19/67	298
	PC	274°	1.03	10/16/67	(d)
30-4 No. 4[e]	PC	348°	8.54	9/19/67	(d)
	PC	348°	8.54	10/24/67	(d)
Indian E No. 1	PC	63°	1.27	9/19/67	(d)
	PC	63°	1.27	10/16/67	493
	PC	63°	1.27	11/21/67	470
Indian H No. 1[f]	PC	128°	4.70	9/19/67	179
	MV	128°	4.70	10/03/67	309
	PC	128°	4.70	10/24/67	199
	MV	128°	4.70	10/24/67	354
	PC	128°	4.70	11/07/67	204
Post-shot samples[c]:					
San Juan					
27-4 No. 1	MV	179°	5.40	1/02/68	34
	MV	179°	5.40	1/30/68	9
28-4 No. 1	MV	260°	4.40	12/27/67	520
28-4 No. 2	MV	251°	4.07	12/27/67	146
28-4 No. 6	PC	218°	.59	2/27/68	288
28-4 No. 7	PC	126°	2.14	2/27/68	239
28-4 No. 8	MV	178°	4.56	1/30/68	1,028
28-4 No. 13	MV	136°	4.60	12/26/67	1,165
28-4 No. 14	MV	228°	4.50	12/27/67	230
28-4 No. 16	MV	235°	5.30	12/26/67	859
28-4 No. 17	MV	240°	3.83	12/26/67	754
28-4 No. 26	MV	255°	5.15	12/20/67	1,628
28-4 No. 27	MV	243°	5.45	12/26/67	1,080
28-4 No. 28	MV	246°	4.79	12/26/67	70
29-4 No. 1	MV	282°	5.12	12/20/67	79
29-4 No. 2	PC	274°	1.03	2/27/68	302
29-4 No. 4	PC	309°	.84	2/27/68	464
29-4 No. 10[g]	PC	344°	.10	NS	
29-4 No. 14	MV	277°	4.45	12/27/67	34
29-4 No. 16	PC	39°	.72	2/27/68	483
29-4 No. 18	MV	280°	2.49	12/26/67	592
30-4 No. 4[e]	PC	348°	8.54	12/12/67	333
Indian A No. 2	PC	43°	1.28	12/27/67	480
Indian E No. 1	PC	63°	1.27	12/27/67	52
Indian I No. 1[f]	MV	139°	5.65	12/19/67	617
	PC	139°	5.65	12/19/67	761
	PC	139°	5.65	1/30/68	9
Indian B No. 1	MV	136°	4.58	12/19/67	216
Indian L No. 2	MV	12[illegible]°	3.96	1/02/68	1[illegible]
Indian H No. 1[f]	PC	128°	4.70	12/19/67	2[illegible]
	MV	128°	4.70	12/19/67	48[illegible]
San Juan					
28-4 No. 21	MV	265°	4.93	12/27/67	634

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[a] Gas bearing formation: MV is Mesa Verde formation, PC is Pictured Cliffs formation.

[b] The minimum level of detection (MLD) for radon-222 is 1 pCi/ft³. Similarly MLD's for other isotopes analyzed are:
xenons —200 pCi/ft³
kryptons —200 pCi/ft³
carbon-14—300 pCi/ft³
tritium — 20 pCi/ft³
All radon-222 values have been corrected for decay to the time of sample collection.

[c] The table only contains concentrations for radon-222. The samples were also analyzed for radioxenons, radiokryptons, carbon-14, and tritium. Results of these analyses were all below minimum detectable levels shown in footnote [b]. All radons on preshot samples were analyzed at the field laboratory in Farmington. All post-shot radon analyses were performed in Las Vegas. The Farmington analyses were carried out on raw natural gas while the Las Vegas analyses were made by separating the radon from the natural gas. The Las Vegas results have been corrected by an appropriate correction factor to make them comparable to the preshot Farmington results.

[d] These samples were not analyzed for radon-222, but were analyzed for xenon and krypton radioisotopes.

[e] This well is located outside of the area bounded by a 6-mile radius from ground surface zero.

[f] Samples from Indian H No. 1 and Indian I No. 1 wells can be taken from one or both the Pictured Cliffs (PC) and Mesa Verde (MV) formations because these wells penetrate both formations.

[g] This well is also called 10-36 and is located 435 feet from ground zero. It was stemmed prior to the event and could not be sampled post-shot.

NS, no sample taken.

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Table 7. Special post-Gasbuggy natural gas samples

Sample description	Collection date (1968)	Radon-222 concentrations[a] (pCi/ft^3) Average of 3 analyses
Mainline, blockvalve 3-mile post 36 +	4/24	260
	4/24	404
24-inch main and loop blockvalve 2	4/24	475
24-inch main, blockvalve 2	4/24	713
San Juan 29–5 unit 45 22 MD–R.A. Mesa Verde	4/25	1,005
San Juan 28–5 unit 55 R.A. Mesa Verde	4/25	1,132
San Juan 28–5 unit 45 R.A. Dakota	4/25	275
San Juan 28–5 unit 19 R.A. Picture Cliffs	4/25	484
San Juan 27–4 unit 13 R.A. Picture Cliffs	4/25	[b] 761
San Juan 30–4 unit 4 R.A. Picture Cliffs	4/25	405
Ehrenberg meter station	4/26	164
Topok meter station	4/26	294

[a] Corrected for decay to the time of sample collection.

[b] Duplicate analysis.

Note: Each sample was analyzed for tritium, carbon–14, radioxenon, and radiokrypton. No radioactivity was detected above minimum detectable levels of 20, 300, 200, and 200 pCi/ft^3, respectively.

Representative products and manufacturers are named for identification only and listing does not imply endoresement by the Public Health Service and the U.S. Department of Health, Education, and Welfare.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE. Radiation Alert Network, December 1967. Radiol Health Data Rep 9:226–229 (April 1968).

(*2*) BUNCE, L. A. and F. W. SATTLER. Radon-222 in natural gas. Radiol Health Data Rep 7:441–444 (August 1966).

Technical Notes

Evaluation of Radium-226 in Total Diet Samples, 1964 to June 1967[1]

Northeastern Radiological Health Laboratory
Bureau of Radiological Health

A summary of concentrations of radium-226 in total diet samples collected by the Institutional Total Diet Network, Bureau of Radiological Health, from 1964 to the middle of 1967, is presented in this report. The purpose of this summarization is to characterize the internal exposure to the population from ingested radium-226 and to determine if significant environmental differences due to geographical or seasonal variations influence the concentration of this radionuclide in the total diet.

The data used in this evaluation were obtained from *Radiological Health Data and Reports* (*1*). A detailed description of sampling and analytical procedures is presented in reference 2. The minimum detectable sensitivity for analysis of radium-226 in food is 0.1 pCi/kg.

The following locations provided a sufficient amount of continuous data for this evaluation:

Boston, Mass.
Chicago, Ill.
Cleveland, Ohio
Burlington, Vt.
Palmer, Alaska
Seattle, Wash.
Denver, Colo.
Pittsburgh, Pa.
Idaho Falls, Idaho
Honolulu, Hawaii
Wilmington, Del.

The data from each location were plotted on arithmetic probability paper in order to characterize some common statistical variables. These graphs are shown in figures 1, 2, and 3. Results from Chicago, Ill.; Boston, Mass.; Cleveland, Ohio; and Burlington, Vt. (figure 1) show a normal distribution. Data from Denver, Colo.; Seattle, Wash.; Pittsburgh, Pa.; and Palmer, Alaska (figure 2) have a bimodal distribution, with a discontinuity above the 87 percentile (1.5σ level). Wilmington, Del., and Honolulu, Hawaii, also have bimodal distributions with the discontinuity occurring at approximately the 25 percentile. Idaho Falls, Idaho, appears to have a trimodal distribution. These latter graphs appear in figure 3. Changes in sampling methods and sites, and in analytical procedures, cannot be ruled out as possible factors in causing the resultant distribution to vary from normal. Information on environmental variables which might influence the distribution of the data is lacking, but plotting the data against a time scale appears to indicate that the variations in the data at any one location are not related to seasonal factors.

The mean, 1σ range and 1.5σ range for radium-226 concentrations in total diet samples from 1964 to the middle of 1967 are shown in table 1. The

Table 1. Radium-226 in total diet from 1964 to the middle of 1967

Sampling location		Mean	Concentration (pCi/kg) 1σ range	1.5σ range
Mass:	Boston	0.52	0.44–0.60	0.35–0.71
Alaska:	Palmer	.54	.43– .64	.31– .78
Ill:	Chicago	.58	.51– .67	.40– .78
Idaho:	Idaho Falls	.58	.48– .68	.41– .82
Wash:	Seattle	.61	.40– .72	.38– .85
Colo:	Denver	.61	.40– .72	.38– .85
Ohio:	Cleveland	.62	.52– .71	.42– .83
Vt:	Burlington	.62	.52– .74	.42– .88
Hawaii:	Honolulu	.64	.51– .77	.46– .88
Del:	Wilmington	.70	.61– .85	.48–1.12
Pa:	Pittsburgh	.73	.66– .84	.56– .95
Summary			0.40–0.85	0.31–1.12

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[1] Special report prepared by Dr. Bernard Shleien, chief, Environmental Radiation Activities, Northeastern Radiological Health Laboratory, Winchester, Mass.

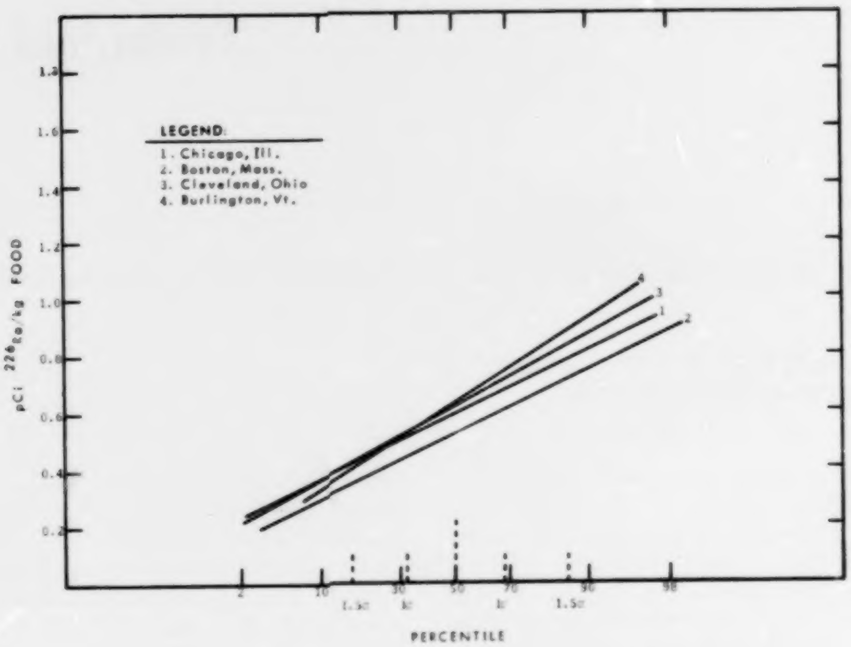

Figure 1. Percentile distribution of radium-226 in total diet for four selected cities

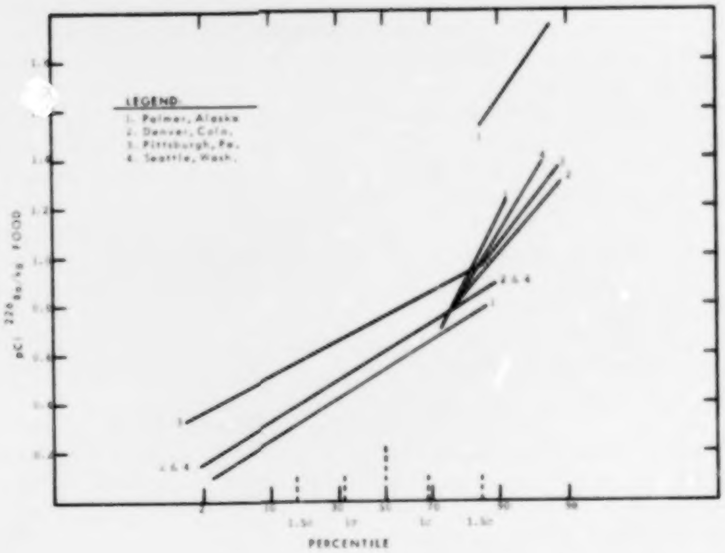

Figure 2. Percentile distribution of radium-226 in total diet for four selected cities

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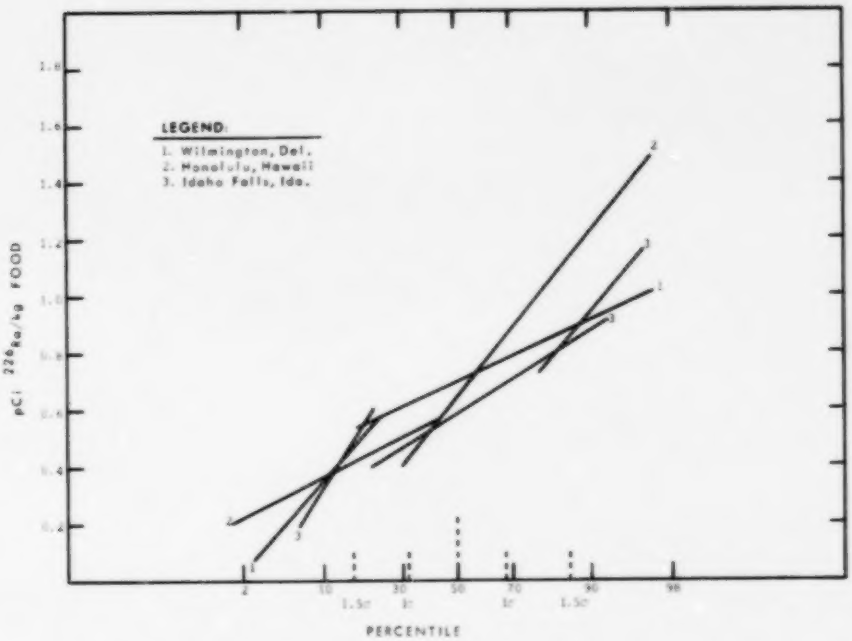

Figure 3. Percentile distribution of radium-226 in total diet for three selected cities

mean values varied from 0.52 to 0.73 pCi/kg. In no case was the 1.5σ range greater than 60 percent of the mean value. In other words, 87 percent of the results at any one station were within 60 percent of the mean value. In considering all the data, 87 percent of the results fell between 0.31 pCi/kg and 1.12 pCi/kg, a factor of slightly less than 4.

Assuming a food consumption of 2 kg per day, these results indicate that radium-226 intake is for the most part in Range I (0-2 picograms per day) of the Federal Radiation Council's guidance on transient rates of daily intake of radium-226 and would not be expected to result in any appreciable number of individuals in the population reaching a large fraction of the Radiation Protection Guide (*3*). The FRC then states: "Therefore, if calculations based upon a knowledge of the sources of release of radioactive materials to the environment indicate that the intakes of the population are in this range the only action required is surveillance adequate to provide reasonable confirmation of calculations."

In summary, results of three and one-half years of total diet surveillance at eleven diverse geographical locations indicate that approximately 87 percent of the samples analyzed for radium-226 would result in daily human intakes within Range I of the FRC recommendations for this radionuclide. Therefore, it appears that this is "surveillance adequate to provide reasonable confirmation of calculations." Furthermore, since the sources of release are not usually subject to human manipulation, further evaluation of radium-226 content in food in the manner presently performed appears to be superfluous.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE. Radionuclides in Institutional diet samples, annual averages 1964. Radiol Health Data 6:371-377 (July 1965); annual summary 1965, Radiol Health Data Rep 7:398-403 (July 1966); January-March 1967 and annual summary 1966, Radiol Health Data Rep 8:591-596 (October 1967); October-December and annual summary 1967, Radiol Health Data Rep 9:359-363 (July 1968).

(*2*) PUBLIC HEALTH SERVICE. Radionuclides in Institutional diet samples, January-March 1965. Radiol Health Data 6:548-554 (October 1965).

(*3*) FEDERAL RADIATION COUNCIL. Background materials for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

SECTION I. MILK AND FOOD

Milk Surveillance, August 1969

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation and/or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Bureau of Radiological Health, Environmental Control Administration and the Bureau of Compliance, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Public Health Service)—5 sampling stations
Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that occur in or are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium–89, strontium–90, iodine–131, cesium–137, and barium–140. A sixth radionuclide, potassium–40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium–40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have

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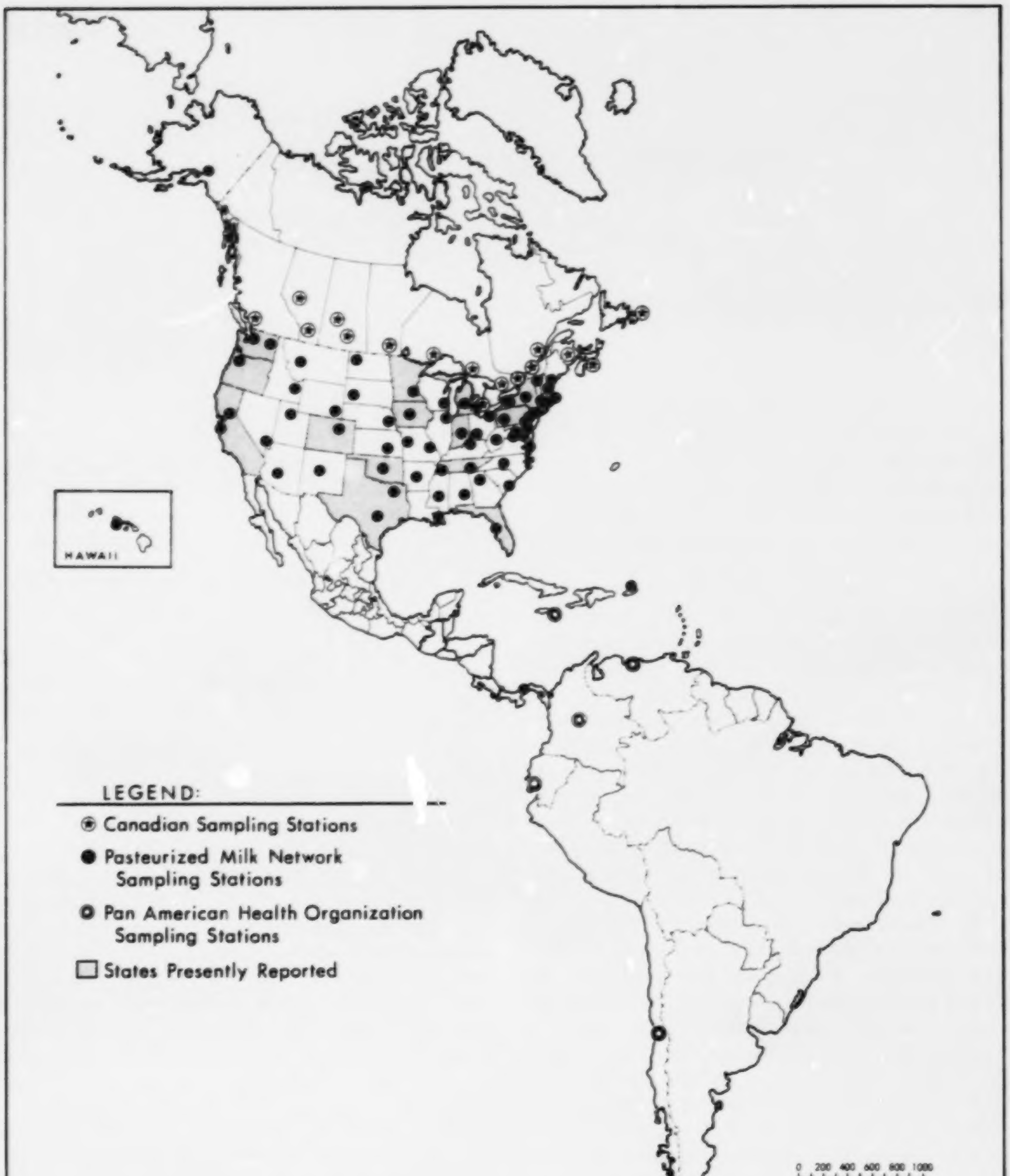
HAWAII
LEGEND:
Canadian Sampling Stations
Pasteurized Milk Network Sampling Stations
Pan American Health Organization Sampling Stations
States Presently Reported
0 200 400 600 800 1000
Scale in Miles

Figure 1. Milk sampling networks in the Western Hemisphere

been measured extensively and are relatively constant. Appropriate values and their variation, expressed in terms of 2-standard deviations, for these concentrations are 1.16 ± 0.08 g/liter and 1.51 ± 0.21 g/liter for calcium and potassium, respectively. These figures are averages of data from the PMN for the period, May 1963–March 1966 (*3*) and were determined for use of general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Bureau of Radiological Health conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted in December 1968, with 37 laboratories participating in an experiment on milk samples containing known concentrations of strontium–89, strontium–90, iodine–131, and cesium 137. Of the 19 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 18 participated in the experiment.

In general the results for iodine–131 and cesium–137 are encouraging, but the results for strontium–89 and strontium–90 need improvement (*5*). Keeping these possible differences in mind, integration of the data from the various networks can be undertaken without introducing a serious error due to disagreement among the independently obtained data.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methodologies, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium–40, iodine–131, cesium–137, and barium–140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A recent article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data articles for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. The frequency of collection and analysis varies not only among the networks, but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium–90 and cesium–137 are relatively stable over short-time periods and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine–131, the frequency of analysis is critical, and is generally increased at the first measurement or recognition of a new influx of the radionuclide.

The data presentation also reflects whether raw or pasteurized milk was collected. A recent analysis (*7*) of raw and pasteurized milk samples collected during the period, January 1964 to June 1966, indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant. Particular attention was paid to strontium–90 and cesium–137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-

standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses experiments (*3*). The practical reporting level reflects additional analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurement equal to or below these practical reporting levels for calculation purposes, particuularly in calculating monthly averages, is discussed in the data presentation.

Analytical errors of precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium-89	1-5 pCi/liter for levels <50 pCi/liter; 5-10% for levels ≥50 pCi/liter
Strontium-90	1-2 pCi/liter for levels <20 pCi/liter; 4-10% for levels ≥20 pCi/liter
Iodine-131 Cesium-137 Barium-140	4-10 pCi/liter for levels <100 pCi/liter; 4-10% for levels ≥100 pCi/liter

For iodine-131, cesium-137, and barium-140 there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions is presented below. The function of the Council is to provide guidance to Federal agencies in the formulation of radiation standards.

Radiation Protection Guides (*8,9*)

The Radiation Protection Guide (RPG) has been defined by the Federal Radiation Council (FRC) as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practical. An RPG provides radiation protection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risk to the general public that might result from exposures from routine uses of ionizing radiation and the benefits from the activities causing the exposure.

Table 1 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable. A more detailed discussion of these values was presented earlier (*3*).

In the absence of specific dietary data one can use milk as the indicator food item for routine surveillance. Assuming a 1-liter per day intake of milk, one can utilize the graded approach of daily intake on the basis of radionuclide content in milk samples collected to represent general population consumption. Under these assumptions, the radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Table 1. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Radionuclide	Critical organ	RPG for individual in the general population (rad/yr)	RPG (rad/yr)	Guidance for suitable samples of exposed population group[a]			
				Corresponding continuous daily intake (pCi/day)	Range I[b] (pCi/day)	Range II[b] (pCi/day)	Range III[b] (pCi/day)
Strontium-89	Bone Bone marrow	[c] 1.5 [c] .5	0.5 .17	[d] 2,000	0-200	200-2,000	2,000-20,000
Strontium-90	Bone Bone marrow	[c] 1.5 [c] .5	.5 .17	[d] 200	0-20	20-200	200-2,000
Iodine-131	Thyroid	1.5	.5	100	0-10	10-100	100-1,000
Cesium-137[e]	Whole body	.5	.17	3,600	0-360	360-3,600	3,600-36,000

[a] Suitable samples which represent the limiting conditions for this guidance are: strontium-89, strontium-90—general population; iodine-131—children 1 year of age: cesium-137—infants.

[b] Based on an average intake of 1 liter of milk per day.

[c] A dose of 1.5 rad/yr to the bone is estimated to result in a dose of 0.5 rad/yr to the bone marrow.

[d] For strontium-89 and strontium-90, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third the respective RPG.

[e] The guides expressed here were not given in the FRC reports, but were calculated using appropriate FRC recommendations.

Protection Action Guide (*10,11*)

The Protective Action Guide (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the accidental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a 1 or 2-year period in a particular area would require special consideration. Protective actions are appropriate when the health benefits associated with the reduction in exposure to be achieved are sufficient to offset the undesirable features of the protective actions.

Table 2 presents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable. A more detailed discussion of these values was presented earlier (*3*). Also given in table 2 are milk concentrations for each of the radionuclides considered, in the absence of others, which if attained after an acute incident, would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentration from an idealized model for any acute deposition and the pasture-cow-milk-man pathway, as well as an estimate of the intake prior to reaching the

Table 2. Protective Action Guides—FRC recommendations and related information pertaining to environmental levels during an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Maximum concentration in milk for single nuclide that would result in PAG (pCi/liter)
Strontium-89	Bone marrow	10 in first yr; total dose not to exceed 15[a,b]	3 in first yr; total dose not to exceed 5[a,b]	[c] 1,110,000
Strontium-90	Bone marrow			[c] 51,000
Cesium-137	Whole body			[c] 720,000
Iodine-131	Thyroid	30	10	[d] 70,000

[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.

[b] Total dose from strontium-89 and cesium-137 is the same as dose in first year; total dose from strontium-90 is 5 times strontium-90 dose in first year for children approximately 1 year of age.

[c] These values represent concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.

[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration observed in milk from an acute contaminating event. A maximum of 84,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered. Children, 1 year of age, are assumed to be the critical segment of the population.

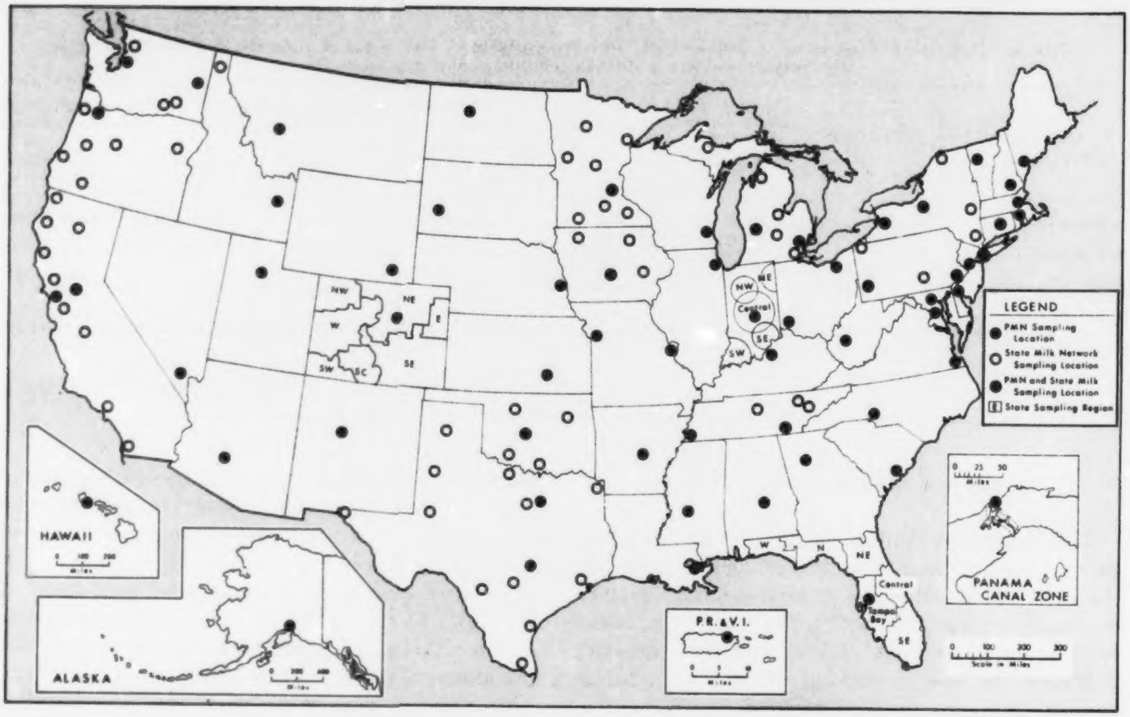

Figure 2. State and PMN milk sampling locations in the United States

maximum concentration. Therefore, these maximum concentrations are intended for use in estimating future intake on the basis of a few early samples rather than in a retrospective manner.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12-monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Data reporting format

Table 3 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports*. (The relationship between the PMN stations and State stations is shown in figure 2.) The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

Discussion of current data

In table 3, surveillance results are given for strontium-89, strontium-90, iodine-131, and cesium-137 for August 1969 and the 12-month period, September 1968–August 1969. Except where noted the monthly average represents a single sample for the sampling station. Barium-140 data has been omitted from table 3 since levels at all the stations for August 1969 were below the respective practical reporting levels.

Iodine-131 results are included in the table, even though they were generally below practical

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Table 3. Concentration of radionuclides in milk for August 1969 and 12-month period, September 1968 through August 1969

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)							
			Strontium-89		Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES										
Ala:	Montgomery[c]	P	4 (4)	1	4 (4)	6	0 (4)	0	15 (4)	11
Alaska:	Palmer[c]	P	NS	0	NS	6	NS	0	NS	9
Ariz.:	Phoenix[c]	P	0	0	0	1	0 (4)	0	0 (4)	0
Ark:	Little Rock[c]	P	4 (4)	1	16 (4)	18	0 (4)	0	23 (4)	18
Calif:	Sacramento[c]	P	0	0	0	2	0 (4)	0	0 (4)	1
	San Francisco[c]	P	0	0	0	2	0 (4)	0	0 (4)	0
	Del Norte	P	6	8	14	21	0	0	0	17
	Fresno	P	0	0	0	0	0	0	0	1
	Humboldt	P	0	2	4	5	0	0	0	9
	Los Angeles	P	0	0	0	1	0	0	0	2
	Mendocino	P	0	0	3	3	0	0	0	2
	Sacramento	P	0	0	0	3	0	0	0	2
	San Diego	P	0	0	0	0	0	0	0	1
	Santa Clara	P	0	0	0	0	0	0	0	3
	Shasta	P	0	0	0	3	0	0	0	5
	Sonoma	P	0	0	0	2	0	0	0	2
Colo:	Denver[c]	P	7	2	3	5	0 (4)	0	0 (4)	2
	Western	R	NS		NS		NS		NS	
	Northeastern	R	NS		NS		NS		NS	
	Eastern	R	NS		NS		NS		NS	
	Southeast	R	NS		NS		NS		NS	
	South Central	R	NS		NS		NS		NS	
Conn:	Hartford[c]	P	(d)	0	10	8	0 (4)	0	11 (4)	12
	Central	P	0	0	9	7	0 (4)	0	16 (4)	10
Del:	Wilmington[c]	P	(d)		11	9	0 (4)	0	12 (4)	8
D.C.:	Washington[c]	P	0 (5)	1	8 (5)	8	0 (5)	0	8 (5)	4
Fla:	Tampa[c]	P	2 (4)	0	5 (4)	7	0 (4)	0	65 (4)	61
	West	R	(d)		14	12	0	0	27	24
	North	R	(d)		13	14	0	0	20	32
	Northeast	R	(d)		7	8	0	0	78	67
	Central	R	(d)		7	8	0	0	70	61
	Tampa Bay area	R	(d)		6	8	0	0	64	66
	Southeast	R	(d)		7	9	0	0	101	111
Ga:	Atlanta[c]	P	0 (4)	0	9 (4)	11	0 (4)	0	18 (4)	19
Hawaii:	Honolulu[c]	P	0 (4)	0	0 (4)	3	0 (4)	0	0 (4)	1
Idaho:	Idaho Falls[c]	P	10	2	3	5	0 (4)	0	3 (4)	7
Ill:	Chicago[c]	P	9	2	8	8	0 (4)	0	7 (4)	10
Ind:	Indianapolis[c]	P	(d)		8	8	0 (4)	0	8 (4)	6
	Northeast	P	0	0	10	12	0	0	15	10
	Southeast	P	0	0	5	8	0	0	15	15
	Central	P	0	0	6	10	0	0	10	10
	Southwest	P	0	0	7	8	0	0	15	10
	Northwest	P	0	0	8	10	0	0	25	15
Iowa:	Des Moines[c]	P	7	1	6	6	0 (4)	0	3 (4)	3
	Iowa City	P	NS		NS	NS	NS		NS	
	Des Moines	P	NS		NS	NS	NS		NS	
	Spencer	P	NS		NS	NS	NS		NS	
	Charles City	P	NS		NS	NS	NS		NS	
Kans:	Wichita[c]	P	6	1	7	7	0 (4)	0	0 (4)	2
Ky:	Louisville[c]	P	3 (4)	2	9 (4)	10	0 (4)	0	5 (4)	6
La:	New Orleans[c]	P	8 (4)	2	16 (4)	17	0 (4)	0	21 (4)	20
Maine:	Portland[c]	P	(d)		14	12	0 (4)	1	39 (4)	25
Md:	Baltimore[c]	P	1 (4)	1	8 (4)	9	0 (4)	0	14 (4)	7
Mass:	Boston[c]	P	7	1	15	11	0 (5)	0	27 (5)	21
Mich:	Detroit[c]	P	(d)		8	8	0 (4)	0	6 (4)	10
	Grand Rapids[c]	P	(d)		12	11	0 (4)	0	10 (4)	14
	Bay City	P	(d)		NS	5	NS	(e)	NS	11
	Charlevoix	P	(d)		10	10	(e) (3)	(e)	26 (3)	18
	Detroit	P	(d)		5	5	(e) (4)	(e)	9 (4)	5
	Grand Rapids	P	(d)		7	7	(e) (4)	(e)	16 (4)	11
	Lansing	P	(d)		8	5	(e) (2)	(e)	20 (2)	8
	Marquette	P	(d)		10	9	8 (2)	(e)	31 (2)	28
	Monroe	P	(d)		3	3	(e) (2)	(e)	6 (2)	1
	South Haven	P	(d)		NS	7	NS	(e)	NS	8
Minn:	Minneapolis[c]	P	12	2	7	10	0 (4)	0	16 (4)	12
	Bemidji	P	(d)		20	17	0	0	35	23
	Mankato	P	(d)		10	7	0	0	0	0
	Rochester	P	(d)		10	9	0	0	11	0
	Duluth	P	(d)		22	19	0	0	22	26
	Worthington	P	(d)		8	8	0	0	0	0
	Minneapolis	P	(d)		14	12	0	0	11	11
	Fergus Falls	P	(d)		10	8	0	0	0	0
	Little Falls	P	(d)		10	10	0	0	12	15
Miss:	Jackson[c]	P	0 (4)	1	13 (4)	14	0 (4)	0	14 (4)	15
Mo:	Kansas City[c]	P	6	4	11	7	0 (5)	0	3 (5)	2
	St. Louis[c]	P	7	1	7	9	0 (4)	0	3 (4)	4
Mont:	Helena[c]	P	0	1	4	5	0 (4)	0	3 (4)	7
Nebr:	Omaha[c]	P	6	3	6	6	0 (5)	0	0 (5)	2
Nev:	Las Vegas[c]	P	0	0	0	1	0 (4)	0	0 (4)	1
N.H.:	Manchester[c]	P	(d)		8	9	3 (4)	0	22 (4)	24
N.J.:	Trenton[c]	P	(d)		13	9	0 (5)	0	13 (5)	9

See footnotes at end of table.

Table 3. Concentration of radionuclides in milk for August 1969 and 12-month period September 1968 through August 1969—Continued

Sampling location	Type of sample[a]	Radionuclideconcentration (pCi/liter)							
		Strontium-89		Strontium-90		Iodine-131		Cesium-137	
		Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—Con									
N. Mex: Albuquerque[e]	P	0	0	0	2	0 (4)	0	0 (4)	1
N.Y.: Buffalo[e]	P	0 (2)	0	8 (2)	7	0 (4)	0	15 (4)	9
New York City[e]	P	(d)		13	10	0 (4)	0	15 (4)	13
Syracuse[e]	P	(d)		10	8	0 (4)	0	8 (4)	8
Albany	P	9	0	6	7	0 (3)	0	(e) (3)	(e)
Buffalo	P	16	0	0	5	0	0	(e)	(e)
Massena	P	12	0	8	10	0 (2)	0	(e) (2)	(e)
Newburg	P	0	0	0	11	0	0	(e)	(e)
New York City	P	10	0	6	11	0 (3)	0	(e)	(e)
Syracuse	P	11	0	0	8	0	0	(e)	(e)
N.C.: Charlotte[e]	P	0 (3)	1	12 (3)	15	0 (3)	0	17 (3)	12
N. Dak: Minot[e]	P	14	4	9	10	0 (4)	0	12 (4)	13
Ohio: Cincinnati[e]	P	(d)		10	8	0 (3)	0	0 (3)	3
Cleveland[e]	P	(d)		9	8	0 (4)	0	7 (4)	7
Okla: Oklahoma City[e]	P	0	1	7	8	0	0	14	10
Oklahoma City	P	NS		NS		NS		NS	
Enid	P	NS		NS		NS		NS	
Tulsa	P	NS	NS	NS		NS		NS	
Lawton	P	NS		NS		NS		NS	
Admore	P	NS		NS		NS		NS	
Ore: Portland[e]	P	0	2	8	7	0 (4)	0	1 (4)	8
Baker	P	(d)		NA	3	(e)	(e)	(e)	8
Coos Bay	P	(d)		NA	6	(e)	(e)	(e)	12
Eugene	P	(d)		NA	4	(e)	(e)	30	11
Medford	P	(d)		NA	2	(e)	(e)	23	16
Portland composite	P	(d)		NA	4	(e)	(e)	(e) (3)	6
Portland local	P	(d)		NA	5	(e)	(e)	(e) (3)	1
Redmond	P	(d)		NA	1	(e)	(e)	(e)	5
Tillamook	P	(d)		NA	8	(e)	(e)	20	20
Pa: Philadelphia[e]	P	(d)		11	8	0 (4)	0	8 (4)	5
Pittsburgh[e]	P	(d)		15	12	0 (4)	0	5 (4)	8
Dauphin	P	(d)		11	8	0	2	6	15
Erie	P	(d)		19	11	0	3	19	18
Philadelphia	P	(d)		NS	9	NS	1	NS	14
Pittsburgh	P	(d)		13	10	0	2	25	17
R.I.: Providence	P	(d)		11	9	0 (4)	0	20 (4)	17
S.C.: Charleston[e]	P	0 (4)	0	12 (4)	12	0 (4)	0	29 (4)	24
S. Dak: Rapid City[e]	P	17	4	12	8	0 (3)	0	6 (3)	7
Tenn: Chattanooga[e]	P	2 (4)	2	11 (4)	12	0 (4)	0	18 (4)	13
Memphis[e]	P	0 (4)	1	8 (4)	9	0 (4)	0	6 (4)	6
Chattanooga	P	8	4	14	14	0 (4)	0	14 (4)	16
Clinton	P	0	2	15	16	0	0	0	16
Knoxville	P	0	1	11	11	0 (2)	1	7 (2)	8
Nashville	P	0	2	9	9	0 (3)	0	15 (3)	6
Tex: Austin[e]	P	0 (4)	0	4 (4)	2	0 (4)	0	5 (4)	4
Dallas[e]	P	0 (4)	1	5 (4)	7	0 (4)	0	3 (4)	6
Amarillo	R	(d)		4	3	0	0	0	0
Corpus Christi	R	(d)		2	4	0	0	0	0
El Paso	R	(d)		2	2	0	0	0	0
Fort Worth	R	(d)		4	5	0 (4)	0	0	5
Harlengen	R	(d)		3	3	0	0	0	0
Houston	R	(d)		6	7	0	0	15	19
Lubbock	R	(d)		4	3	0	0	0	0
Midland	R	(d)		2	2	0	0	0	0
San Antonio	R	(d)		5	3	0	0	0	0
Texarkana	R	(d)		15	12	0	0	15	16
Uvalde	R	(d)		2	1	0	0	0	0
Wichita Falls	R	(d)		NS	7	NS	0	NS	10
Utah: Salt Lake City[e]	P	8	1	0	4	0 (4)	0	4 (4)	8
Vt: Burlington[e]	P	(d)		9	8	0 (4)	0	15 (4)	12
Va: Norfolk[e]	P	4 (5)	0	11 (5)	10	0 (5)	0	8 (5)	7
Wash: Seattle[e]	P	0	1	10	8	0 (4)	0	9 (4)	16
Spokane[e]	P	0	1	6	6	0 (4)	0	0 (4)	6
Benton County	R	(d)		NS	1	NS	0	NS	6
Franklin County	R	(d)		0	1	0	0	0	0
Sandpoint, Idaho	R	(d)		14	11	0	0	47	27
Skagit County	R	(d)		7	7	0	0	25	13
W. Va: Charleston[e]	P	2 (4)	1	11 (4)	10	0 (4)	0	5 (4)	8
Wisc: Milwaukee[e]	P	(d)		10	7	0 (4)	0	12 (4)	12
Wyo: Laramie[e]	P	0	1	5	5	0 (4)	0	1 (4)	10
CANADA									
Alberta: Calgary	P	(d)		10	8	(d)		26	17
Edmonton	P	(d)		8	7	(d)		24	17
British Columbia: Vancouver	P	(d)		11	13	(d)		41	39

See footnotes at end of table.

Table 3. Concentrations of radionuclides in milk for August 1969 and 12-month period September 1968 through August 1969—Continued

Sampling location	Type of sample[a]	Radionuclide concentration (pCi/liter)							
		Strontium-89		Strontium-90		Iodine-131		Cesium-137	
		Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA—Continued									
Manitoba:									
Winnipeg	P	(d)		9	9	(d)		30	26
New Brunswick:									
Frederickton	P	(d)		14	14	(d)		25	20
Newfoundland:									
St Johns	P	(d)		12	18	(d)		61	37
Nova Scotia:									
Halifax	P	(d)		9	10	(d)		24	21
Ontario: Ft. William	P	(d)		13	16	(d)		32	32
Ottawa	P	(d)		8	9	(d)		16	17
Sault Ste. Marie	P	(d)		19	16	(d)		48	34
Toronto	P	(d)		3	5	(d)		9	13
Windsor	P	(d)		4	6	(d)		10	13
Quebec: Montreal	P	(d)		11	9	(d)		18	18
Quebec	P	(d)		9	11	(d)		26	27
Saskatchewan:									
Regina	P	(d)		8	7	(d)		15	15
Saskatoon	P	(d)		7	8	(d)		13	15
CENTRAL AND SOUTH AMERICA:									
Columbia:									
Bogota	P	NS		NS		NS		NS	
Chile: Santiago	P	0	4	0	0	0	0	0	0
Ecuador: Quayquil	P	0	3	0	0	0	0	0	0
Jamaica: Kingston	P	NS		NS		NS		NS	
Venezuela:									
Caracas	P	0	1	3	1	0	0	0	0
Canal Zone:									
Cristobal[c]	P	1 (4)	4	0 (4)	1	0 (4)	0	4 (4)	13
Puerto Rico:									
San Juan[c]	P	3 (4)	0	1 (4)	4	0 (4)	0	17 (4)	8
PMN network averages[f]		3	1	8	8	0	0	10	10

[a] P, pasteurized milk, R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses

[c] PHS Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado—25 pCi/liter
Michigan—14 pCi/liter
Oregon—15 pCi/liter

Cesium-137: Colorado—25 pCi/liter
New York—20 pCi/liter
Oregon—11 pCi/liter

Strontium-90: New York—3 pCi/liter

[f] This entry gives the average radionuclide concentrations for the PHS Pasteurized Milk Network stations denoted by footnote [c].

NA, no analysis.

NS, no sample.

reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council (table 1), levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting levels for iodine-131 are numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium-89 monthly averages ranged from 0 to 17 pCi/liter in the United States for the month of August 1969 and the highest 12-month average was 8 pCi/liter (Del Norte, Calif.) representing 0.4 percent of the recommended guide (table 1). Strontium-90 monthly averages ranged from 0 to 22 pCi/liter for the month of August 1969 and the highest 12-month average was 21 pCi/liter (Del Norte, Calif.) representing 10.5 percent of the recommended guide (table 1). Cesium-137 monthly averages ranged from 0 to 101 pCi/liter in the United States for the month of August 1969 and the highest 12-month average was 111 pCi/liter (southeast Florida), representing 3 percent of the value presented in this report using the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*12*) and Jamaica. Iodine-131 monthly averages were all below the practical reporting level.

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Acknowledgement

Appreciation is expressed to the personnel of the following health agencies who provide data for their milk surveillance networks:

Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiological Health Section
Division of Air, Occupational and Radiation Hygiene
Colorado State Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Division of Radiological Health
Bureau of Preventable Diseases
Florida State Board of Health

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiological Health Service
Division of Occupational Health
Michigan Department of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Health
Division of Environmental Health Services
New York State Department of Health

Division of Occupational and Radiological Health
Environmental Health Services
Oklahoma State Department of Health

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

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(*12*) PORTER, C. R., C. R. PHILLIPS, M. W. CARTER, and B. KAHN. The Cause of Relatively High Cesium-137 Concentrations in Tampa, Florida, Milk. Radioecological Concentration Processes, Proceedings of an International Symposium held in Stockholm, April 25–29, 1966. Pergamon Press, New York, N.Y. (1966) pp. 95–101.

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Issue
California Diet Study	November 1967–September 1968	May 1969
Connecticut Diet Study	January–June 1968	November 1968
Institutional Diet, *PHS*	Annual summary 1968 and January–March 1969	October 1969

1. Strontium-90 in Tri-City Diets[1]
August–December 1968

Health and Safety Laboratory
U.S. Atomic Energy Commission

Estimates of the average intake of strontium-90 by New York City, Chicago, and San Francisco residents have been made by the Health and Safety Laboratory (HASL). These estimates were made by using measurements of the strontium-90 content of a large variety of foods purchased at the cities every 3 months and statistics on the average consumption of each food compiled by the U.S. Department of Agriculture in their 1955 Household Diet Survey (*1*). A detailed description of the aims and methods of the HASL diet sampling program along with a summary of the results obtained during the first 3 years of operation (1960–1963) was published earlier (*2*).

Starting in 1968, two changes have been made in the program because previous experience had shown the levels of strontium-90 in the Chicago diet to be consistently between those of New York City and San Francisco. Thus, reasonable estimates of the dietary intake of strontium-90 in Chicago at any time can be made from the analyses of foods purchased in New York City and San Francisco.

The second change, revision of the estimates of the annual consumption of different diet components, was made because new information became available. This new information on the composition of the diet appeared in a preliminary report of the U.S. Department of Agriculture in their 1965 Household Diet Survey (*3*). The changes in the composition of the diet from 1955 to 1965 are not very great, and the estimates of strontium-90 intake made using statistics from either diet survey are not too different. Estimates of the intakes of other nuclides, however, may be effected to a greater degree. The new estimates of the consumption have therefore been used to calculate the intakes of calcium and strontium-90 for the third and fourth quarters of 1968 in New York City and San Francisco.

Results of the August–September 1968 samplings are presented in table 1; November–December 1968 in table 2. The variation with time of the daily intake of strontium-90 in the three cities is plotted in figure 1.

Table 1. Average dietary consumption and strontium-90 intake in Tri-City diet, August–September 1968

Food category	Diet (kg/yr)	Calcium (g/yr)	New York City August 1968		San Francisco September 1968	
			(pCi/kg)	(pCi/yr)	(pCi/kg)	(pCi/yr)
Dairy products	200	216.0	10.4	2,080	1.7	340
Fresh fruit	59	9.4	18.2	1,074	1.4	83
Fresh vegetables	48	18.7	12.2	586	4.4	211
Root vegetables	10	3.8	4.9	49	4.5	45
Potatoes	38	3.8	9.5	361	1.5	57
Macaroni	3	0.6	4.7	14	2.7	8
Rice	3	1.1	2.3	7	9.7	29
Fruit juices	28	2.5	3.3	92	1.1	31
Canned vegetables	22	4.4	9.3	205	1.9	42
Canned fruit	11	0.6	2.4	26	1.7	19
Dried beans	3	2.1	3.6	11	5.4	16
Flour	34	6.5	6.9	235	3.4	116
Bakery products	44	53.7	5.4	238	4.7	207
Whole grain products	11	10.3	8.5	94	6.3	69
Fresh fish	8	7.6	0.5	4	0.0	0
Shell fish	1	1.6	1.4	1	0.3	0
Poultry	20	6.0	2.4	48	1.1	22
Meat	79	12.6	10.0	79	0.7	55
Eggs	15	8.7	3.4	51	1.5	23
Annual intake		370.0		5,255		1,373
Daily intake (pCi/day)				14.3		3.8

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[1] Data from Fallout Program Quarterly Summary Report, HASL 204, 207. Available from the Clearinghouse for Federal Scientific & Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Va. 22151.

Table 2. Average dietary consumption and *strontim*-90 intake in Tri-City diet, November–December 1968

Food category	Diet (kg/yr)	Calcium (g/yr)	New York City November 1968		San Francisco December 1968	
			(pCi/kg)	(pCi/yr)	(pCi/kg)	(pCi/yr)
Dairy products	200	216.0	10.8	2,160	2.1	420
Fresh fruit	59	9.4	18.0	1,062	4.7	227
Fresh vegetables	48	18.7	17.5	840	2.1	101
Root vegetables	10	3.8	7.9	79	4.8	48
Potatoes	38	3.8	.7	27	5.3	201
Macaroni	3	.6	3.6	11	2.9	9
Rice	3	1.1	8.9	27	1.4	4
Fruit juices	28	2.5	3.0	84	3.8	106
Canned vegetables	22	4.4	9.9	218	1.9	42
Canned fruit	11	.6	1.5	17	.7	8
Dried beans	3	2.1	1.7	5	10.8	32
Flour	34	6.5	6.6	224	3.4	116
Bakery products	44	53.7	6.4	282	4.2	185
Whole grain products	11	10.3	13.6	150	6.0	66
Fresh fish	8	7.6	.4	3	.6	5
Shell fish	1	1.6	1.2	1	1.8	2
Poultry	20	6.0	1.2	24	1.5	30
Meat	79	12.6	1.5	119	.5	40
Eggs	15	8.7	2.1	32	1.7	26
Annual intake		370.0		5,365		1,718
Daily intake (pCi/day)				14.7		4.7

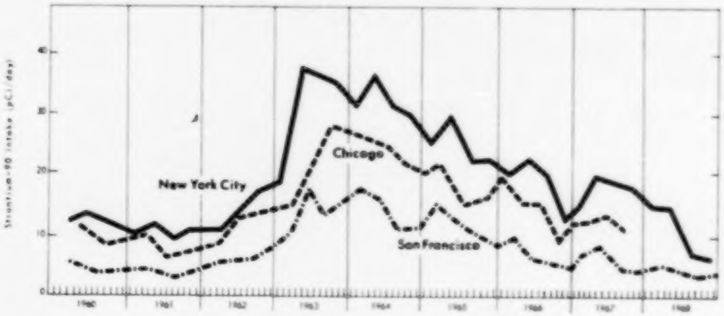

Figure 1. Daily intake of strontium-90 in Tri-City diet
March 1960–December 1968

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(*1*) U.S. DEPARTMENT OF AGRICULTURE. Food consumption of households in the United States, household food consumption survey, Report No. 1, (1955). Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 (December 1956).

(*2*) RIVERA, J., and J. H. HARLEY. HASL contributions to the study of fallout in food chains, HASL-137. Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (July 1, 1964).

(*3*) U.S. DEPARTMENT OF AGRICULTURE. Food Consumption of Households in the United States, Spring 1965. A Preliminary Report, U.S.D.A., ARS 62-16 (August 1967.)

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
April–December 1967	June 1968
January–June 1968	April 1969

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SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

Water sampling program	Period reported	Issue
Colorado River Basin	1967	December 1968
Drinking Water Analysis Program	1961–1966	August 1968
Florida	1967	February 1969
Kansas	July–December 1967	November 1968
Minnesota	July–December 1968	November 1969
New York	July–December 1968	September 1969
North Carolina	January–December 1967	May 1969
Radiostrontium in Tap Water, HASL	July–December 1968	November 1969
Washington	July 1967–June 1968	June 1969

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90 respectively.

REFERENCES

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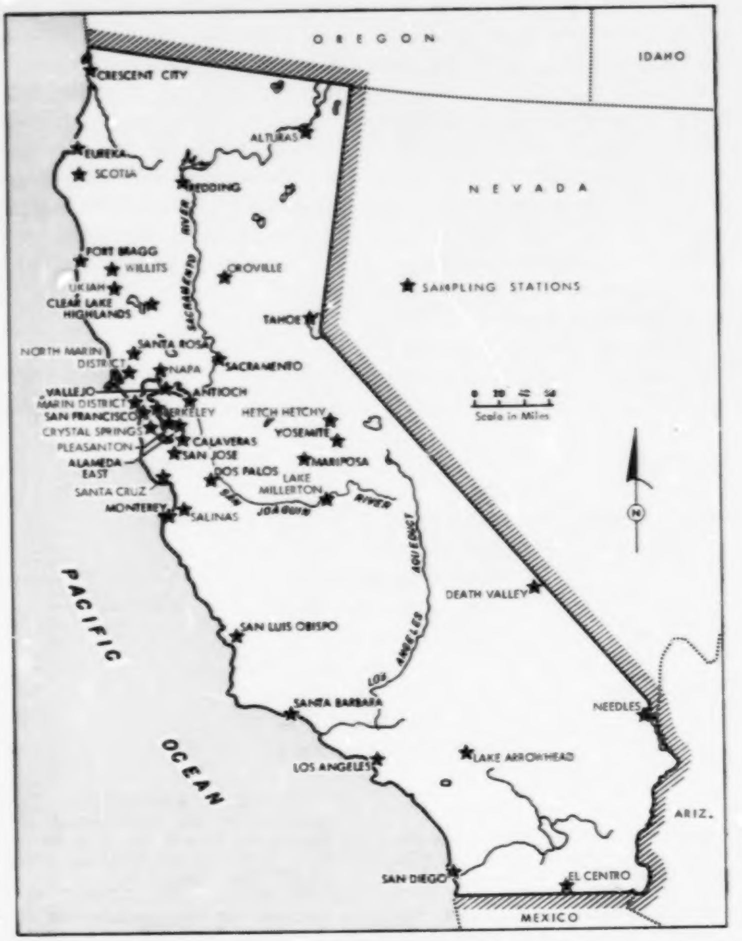
Radioactivity in California Waters,[1] January-June 1968

Bureau of Radiological Health, State of California Department of Public Health

Gross beta radioactivity in California domestic waters is monitored by the State of California's Bureau of Radiological Health. The importance of this program in the State's environmental surveillance activities stems from the fact that most of California's domestic water supplies are of surface origin.

Radioactivity in such water supplies consists of the natural radioactivity in surface streams, radioactivity added by the discharge of sewage or by industrial waste effluents, and radioactivity from fallout, particularly fallout into open terminal or distribution reservoirs. Present efforts consist of sampling raw and treated surface waters and well waters. It should be noted that except for large metropolitan water supplies, raw water sampling is being phased out and treated water sampling being substituted or continued. This


OREGON
IDAHO
NEVADA
ARIZ.
MEXICO
PACIFIC
OCEAN
SAMPLING STATIONS
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SCOTIA
REDDING
SACRAMENTO RIVER
FORT BRAGG
WILLITS
OROVILLE
UKIAH
CLEAR LAKE HIGHLANDS
TAHOE
NORTH MARIN DISTRICT
SANTA ROSA
NAPA
SACRAMENTO
VALLEJO
ANTIOCH
MARIN DISTRICT
SAN FRANCISCO
BERKELEY
HETCH HETCHY
CRYSTAL SPRINGS
YOSEMITE
CALAVERAS
PLEASANTON
SAN JOSE
ALAMEDA EAST
MARIPOSA
DOS PALOS
SANTA CRUZ
LAKE MILLERTON
SAN JOAQUIN RIVER
MONTEREY
SALINAS
LOS ANGELES AQUEDUCT
DEATH VALLEY
SAN LUIS OBISPO
SANTA BARBARA
NEEDLES
LAKE ARROWHEAD
LOS ANGELES
SAN DIEGO
EL CENTRO

Figure 1. California surface water sampling stations

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[1] Data from July and October 1968 issues of Radiological Health News, State of California, Department of Public Health, Bureau of Radiological Health, 2151 Berkeley Way, Berkeley, Calif. 94704.

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procedural change is predicated upon sampling water at the point of consumption.

Most of the supplies sampled have, as a source, raw surface waters (figure 1), although a few wells, along with some water supplies that use infiltration galleries, are also sampled.

Monitoring of domestic water supplies is on a continuing basis, since it has not been possible to forecast levels of radioactivity in these supplies based upon levels in rain, snow, or surface streams. Under the present sampling schedule, monthly 500 ml samples are collected and the total solids analyzed for alpha and beta radioactivity. In addition, 3-liter samples are collected monthly for approximately 6 months and composited for specific radionuclide analysis on a semiannual basis.

Analytical procedures

Radionuclide analyses of water are carried out in the State's Sanitation and Radiation Labora-

Table 1. Gross beta radioactivity in California domestic waters January–June 1968

Sampling station	Quality	Concentration (pCi/liter)					
		January	February	March	April	May	June
Alturas	Well	[a]12	[a]33	NS	NS	ND	[a]20
Antioch	Treated	ND	[a]2	ND	ND	[a]6	14
Berkeley	Treated	ND	ND	[a]5	[a]5	ND	[a]12
Clearlake Highlands	Treated	[a]5	ND	[a]10	[a]6	[a]8	[a]11
Crescent City	Well	ND	[a]4	[a]15	ND	ND	[a]3
Death Valley	Treated	[a]19	[a]7	[a]6	ND	[a]4	[a]13
Dos Palos	Treated	[a]7	ND	[a]22	[a]8	ND	ND
Eureka	Raw	ND	[a]2	[a]20	[a]10	[a]19	[a]11
	Treated	ND	ND	ND	[a]11	ND	[a]3
Fort Bragg	Treated	ND	[a]18	ND	NS	NS	[a]12
Lake Arrowhead	Treated	ND	[a]11	[a]9	[a]7	NS	[a]21
Lake Millerton	Raw	[a]5	ND	ND	[a]2	[a]2	[a]5
Los Angeles Laboratory	Raw	[a]7	[a]8	[a]9	NS	NS	ND
Marin Municipal Water District	Treated	NS	NS	NS	[a]10	ND	ND
Mariposa	Treated	NS	NS	NS	ND	ND	[a]1
Metropolitan Water District of Southern California: Weymouth Plant	Treated	[a]7	[a]33	NS	31	40	54
Monterey	Treated	48	ND	ND	[a]8	[a]9	[a]5
Napa	Treated	ND	ND	[a]7	[a]2	[a]9	[a]11
Needles	Well	ND	[a]6	[a]27	[a]4	61	[a]4
North Marin Water District	Treated	ND	[a]12	[a]5	ND	[a]35	[a]8
	Raw	116	[a]25	ND	[a]12	[a]11	[a]7
	Sludge[b]	45	[a]17	40	[a]42	[a]20	ND
Oroville: Wyandotte Irrigation District	Treated	[a]8	NS	[a]13	[a]22	ND	[a]2
Pleasanton	Well	ND	ND	ND	[a]8	[a]4	ND
Redding	Treated	NS	NS	NS	NS	NS	[a]6
Sacramento: American River	Treated	NS	NS	[a]10	[a]2	ND	[a]36
Sacramento River	Treated	NS	NS	[a]2	[a]12	[a]4	3
San Diego	Raw	[a]7	[a]2	[a]5	[a]17	[a]16	[a]12
	Treated	87	[a]18	[a]3	[a]16	[a]14	54
San Francisco: Water Department	Raw	ND	ND	ND	[a]11	[a]16	[a]1
Alameda East	Raw	ND	[a]1	[a]9	[a]2	ND	[a]3
Brightside Weir	Raw	ND	ND	[a]5	ND	[a]4	ND
Calaveras Reservoir	Raw	8	ND	[a]7	ND	[a]2	[a]5
Crystal Springs	Raw	[a]2	[a]6	[a]14	ND	[a]14	ND
Hetch Hetchy	Raw	[a]9	[a]2	[a]22	[a]5	[a]13	ND
San Jose	Raw	ND	ND	[a]4	ND	ND	[a]2
San Luis Obispo	Treated	ND	ND	NS	NS	NS	NS
Santa Barbara	Treated	[a]26	[a]1	ND	ND	ND	[a]4
Santa Cruz	Raw	ND	[a]3	ND	ND	[a]11	ND
	Treated	113	NS	NS	NS	NS	NS
Santa Rosa	Raw	ND	ND	NS	ND	[a]3	[a]2
	Well	[a]4	ND	ND	NS	NS	NS
Scotia	Raw	[a]5	3	[a]15	[a]3	[a]6	[a]7
	Treated	[a]32	ND	ND	[a]1	[a]9	ND
Ukiah	Well	92	ND	[a]16	ND	[a]12	[a]1
Vallejo: Fleming Hill	Raw	[a]6	[a]10	[a]17	[a]15	[a]18	[a]8
	Treated	[a]2	ND	[a]1	[a]4	[a]11	[a]7
Swanzy Reservoir	Treated	[a]23	[a]2	[a]14	[a]22	NS	NS
Willits	Treated	[a]11	[a]3	ND	[a]6	ND	ND
Yosemite	Treated	ND	[a]5	[a]2	[a]12	[a]21	[a]7
Maximum		116	33	40	42	10	54
Minimum		2	1	1	1	2	1

[a] When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best estimate, but is not statistically significant.

[b] Sludge reported in pCi/g (dry weight).

NS, no sample collected.

ND, no detectable activity.

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tory. Measurements of alpha and alpha-plus-beta radioactivities are made with a low-background windowless gas-flow proportional counter. Counting methods used follow those recommended by the U.S. Public Health Service (*1*).

Individual samples are evaporated to dryness and the residue ashed at 450°C. The ashed sample is dissolved and transferred to an aluminum planchet for beta-particle counting. Specific radionuclides are determined semiannually on composite samples. Gamma-ray emitting nuclides are determined by gamma-ray spectroscopy and radium and radiostrontium by chemical separation and counting.

Discussion

Table 1 shows the monthly average beta radioactivity in the suspended-plus-dissolved solids in surface water supplies in California from January through June 1968. Following treatment, these waters are used for industrial and domestic purposes. Because alpha radioactivity in water has, in general, been undetectable or very slight, alpha radioactivity analyses are not presented. No increase in radioactivity level of surface water has been observed.

REFERENCE

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Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1967	June 1968
July–December 1967	November 1968

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta-radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports.*

Network	Period	Issue
Fallout in the United States and Other Areas, HASL	January–June 1968	October 1969
Plutonium in Airborne Particulates and Precipitation	April–June 1968	October 1969

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1. Radiation Alert Network
August 1969

Bureau of Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Bureau of Radiological Health officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Radiological Surveillance Branch, Division of Environmental Radiation, BRH, Rockville, Md. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during August 1969. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.

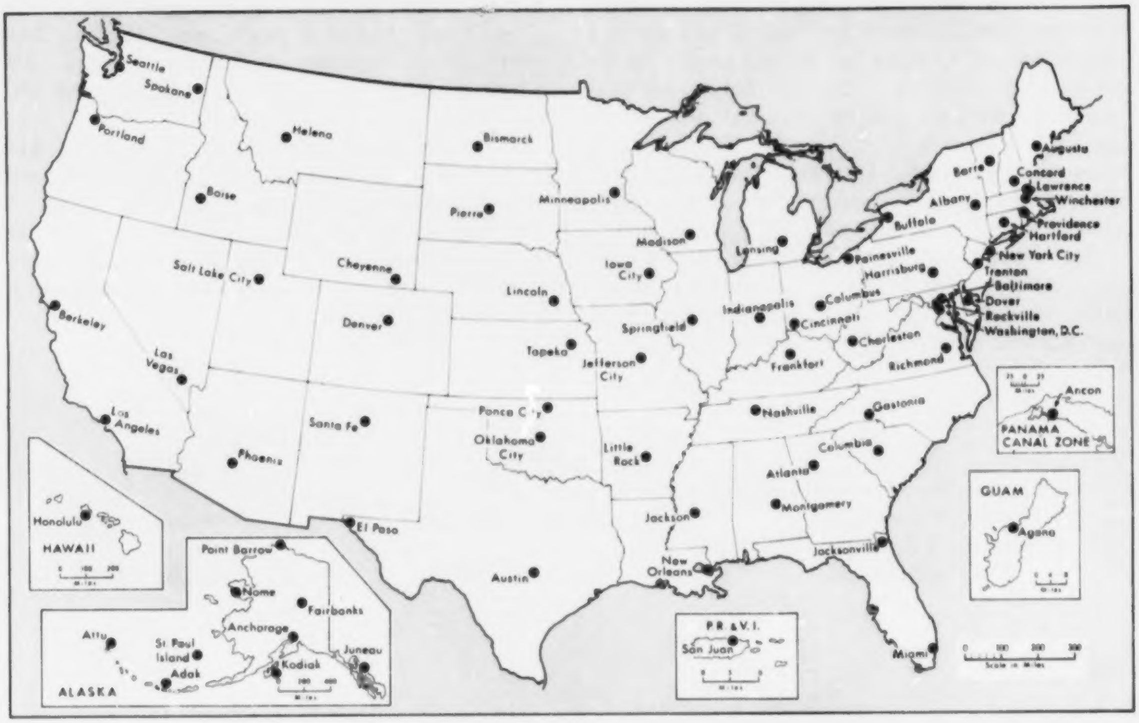
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Salt Lake City
Cheyenne
Lincoln
Madison
Iowa City
Lansing
Berkeley
Denver
Topeka
Springfield
Indianapolis
Columbus
Cincinnati
Charleston
Frankfort
Richmond
Jefferson City
Las Vegas
Los Angeles
Santa Fe
Ponca City
Oklahoma City
Phoenix
Little Rock
Nashville
Gastonia
Columbia
Atlanta
Montgomery
Jackson
El Paso
Austin
New Orleans
Jacksonville
Miami
Augusta
Barre
Concord
Lawrence
Winchester
Albany
Buffalo
Providence
Hartford
Painesville
Harrisburg
New York City
Trenton
Baltimore
Dover
Rockville
Washington, D.C.
Ancon
PANAMA CANAL ZONE
GUAM
Agana
Honolulu
HAWAII
Point Barrow
Nome
Fairbanks
Anchorage
Attu
St Paul Island
Adak
Kodiak
Juneau
ALASKA
PR & V.I.
San Juan
Scale in Miles

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, August 1969

Station location		Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Last profile in RHD&R	Precipitation				
							Number of samples	Total depth (mm)	Field estimation of deposition		
		Air	Maximum	Minimum	Average				Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	21	6	0	2	Dec 69	6	129	6	129	71
Alaska:	Adak	15	1	1	1	Dec 69	(c)				
	Anchorage	8	0	0	0	Aug 69	(c)				
	Attu Island	24	0	0	0	Mar 69	(c)				
	Fairbanks	(b)				Sept 69	(c)				
	Juneau	21	9	0	2	Oct 69	15	209	15	209	0
	Kodiak	(b)				Nov 69					
	Nome	(b)				May 69	(c)				
	Point Barrow	31	1	0	0	Apr 69	(c)				
	St. Paul Island	11	1	1	1	June 69	(c)				
Ariz:	Phoenix	15	7	1	4	Oct 69	(c)				
Ark:	Little Rock	5	7	3	5	Aug 69	(c)				
Calif:	Berkeley	21	1	0	0	Nov 69	(c)				
	Los Angeles	21	2	0	1	May 69	(c)				
C.Z:	Ancon	17	0	0	0	Nov 69	(c)				
Colo:	Denver	19	6	1	4	Nov 69	(c)				
Conn:	Hartford	20	1	0	1	Sept 69	5	47	5	47	0
Del:	Dover	21	5	0	1	July 69	(c)				
D.C:	Washington	20	2	0	1	Apr 69	5	170	5	170	42
Fla:	Jacksonville	21	1	0	0	Aug 69	7	156	7	156	56
	Miami	14	0	0	0	Sept 69	1	5	1	5	0
Ga:	Atlanta	21	4	0	2	June 69	2	79	2	79	50
Guam:	Agana	(b)				July 69	(c)				
Hawaii:	Honolulu	27	1	0	0	Mar 69	(c)				
Idaho:	Boise	21	3	1	2	Mar 69	(c)				
Ill:	Springfield	21	4	1	2	Apr 69	(c)				
Ind:	Indianapolis	11	3	1	2	June 69	2	56	2	56	2
Iowa	Iowa City	16	5	1	2	Nov 69	1	34	1	34	0
Kans:	Topeka	20	7	1	4	Aug 69	3	20	3	20	2
Ky:	Frankfort	9	6	1	3	Apr 69	(c)				
La:	New Orleans	19	1	0	0	Apr 69	9	211	(d)		
Maine:	Augusta	9	2	1	1	Oct 69	1	15	1	15	0
Md:	Baltimore	21	2	0	1	Sept 69	4	33	4	33	40
	Rockville	12	2	0	1	Mar 69	(c)				
Mass:	Lawrence	20	3	0	1	Nov 69	3	33	3	33	0
	Winchester	18	3	0	1	Dec 69	4	49	4	49	0
Mich:	Lansing	19	3	1	2	Mar 69	3	6	3	6	1
Minn:	Minneapolis	20	4	1	2	July 69	2	14	2	14	5
Miss:	Jackson	15	3	0	1	Oct 69	2	77	2	77	0
Mo:	Jefferson City	20	10	2	3	June 69	2	22	2	22	1
Mont:	Helena	21	3	1	2	Dec 69	1	74	1	74	0
Nebr:	Lincoln	15	9	3	6	June 69	2	29	2	26	0
Nev:	Las Vegas	13	2	0	1	Sept 69	(c)				
N.H:	Concord	20	2	1	1	Apr 69	(c)				
N.J:	Trenton	19	2	0	1	Oct 69	6	82	6	82	12
N.Mex:	Santa Fe	9	2	1	1	Dec 69	6	56	6	56	13
N.Y:	Albany	(b)				June 69	(c)				
	Buffalo	21	3	0	1	Nov 69	(c)				
	New York City	19	1	0	1	Dec 69	(c)				
N.C:	Gastonia	16	0	0	0	Nov 69	1	2	(d)		
N.Dak:	Bismarck	21	4	1	3	Apr 69	3	15	3	15	2
Ohio:	Cincinnati	(b)				July 69	(c)				
	Columbus	14	4	0	2	Oct 69	3	70	(e)		
	Painesville	21	4	1	3	Sept 69	3	16	3	16	2
Okla:	Oklahoma City	17	4	0	2	Mar 69	4	44	4	44	2
	Ponca City	21	6	0	2	Sept 69	4	44	4	44	0
Ore:	Portland	18	3	0	1	June 69	1	10	1	10	2
Pa:	Harrisburg	16	2	0	1	June 69	(c)				
P.R:	San Juan	(b)				Oct 69	(c)				
R.I:	Providence	20	6	0	3	Mar 69	6	85	6	85	9
S.C:	Columbia	18	4	0	2	Dec 69	3	49	3	49	17
S.Dak:	Pierre	11	6	1	4	Oct 69	(c)				
Tenn:	Nashville	20	3	0	2	Mar 69	4	83	4	83	0
Tex:	Austin	15	8	2	4	July 69	1	25	(d)		
	El Paso	(b)				Apr 69	(c)				
Utah:	Salt Lake City	30	3	1	2	May 69	4	6	4	6	0
Vt:	Barre	16	5	2	2	Aug 69	8	93	8	93	105
Va:	Richmond	21	2	0	1	Aug 69	4	125	4	125	15
Wash:	Seattle	9	1	0	0	Aug 69	2	3	(d)		
	Spokane	8	2	1	1	July 69	(c)				
W.Va:	Charleston	21	5	0	2	Dec 69	5	150	5	150	19
Wisc:	Madison	20	3	1	1	Aug 69	3	33	3	33	3
Wyo:	Ch[illegible]enne	20	6	1	3	Sept 69	1	5	1	5	1
Network summary		1,163	10	0	2		8	61	4	60	

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] No report received. (Air samples received without field estimate data are not considered by the data program.)
[c] No precipitation sample collected.
[d] This station is part of the plutonium in precipitation network. No gross beta measurements are done.
[e] Samples were collected but no field estimates were received.

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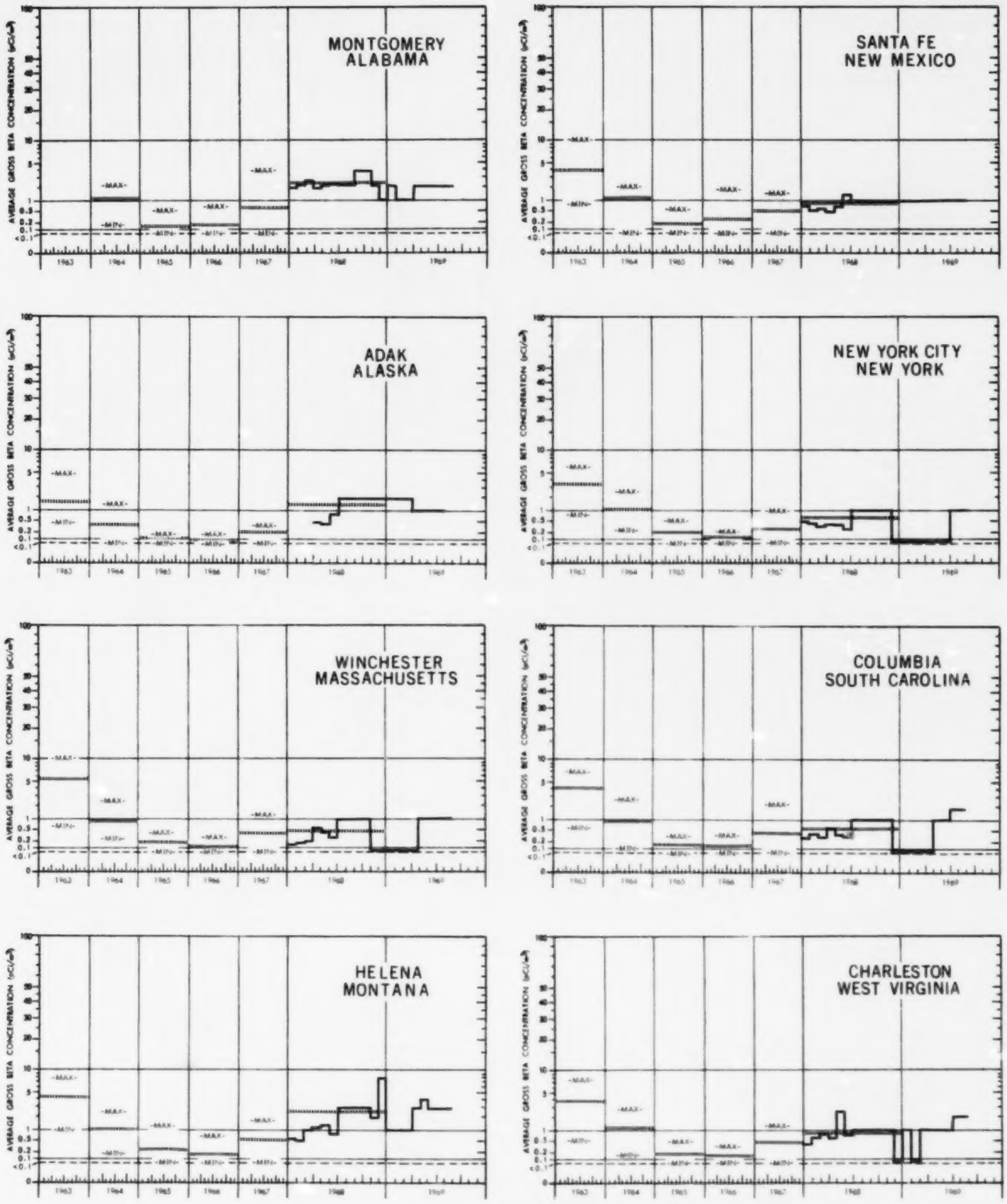

Figure 2. Monthly and yearly profiles of beta radioactivity in air, Radiation Alert Network, 1963–August 1969

2. Canadian Air and Precipitation Monitoring Program[1], August 1969

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meterological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1-5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for August 1969 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, August 1969

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	4	0.4	0.1	0.2	141	2.2
Coral Harbour	29	.3	.0	.2	NS	NS
Edmonton	31	.6	.1	.3	111	13.7
Ft. Churchill	29	.5	.0	.2	96	10.0
Ft. William	7	.4	.2	.3	211	11.4
Fredericton	31	[illegible]	.1	.2	51	3.7
Goose Bay	31	.3	.0	.1	30	4.5
Halifax	30	.4	.0	.2	63	2.8
Inuvik	31	.2	.0	.0	39	6.3
Montreal	30	.6	.1	.4	22	1.9
Moosonee	31	.6	.0	.3	76	7.5
Ottawa	31	.6	.1	.3	90	6.6
Quebec	31	.5	.0	.2	106	12.2
Regina	31	.6	.1	.3	226	10.8
Resolute	31	.3	.0	.1	52	2.1
St. John's, Nfld	31	.3	.0	.2	27	5.8
Saskatoon	30	.5	.1	.3	396	4.6
Saulte Ste Marie	31	.5	.2	.4	102	8.0
Toronto	31	.7	.2	.4	149	4.1
Vancouver	31	.3	.0	.2	79	3.9
Whitehorse	31	.3	.0	.2	86	5.4
Windsor	30	.5	.1	.3	55	6.1
Winnipeg	31	.6	.1	.3	147	8.4
Yellowknife	28	.3	.0	.1	44	6.2
Network summary	682	0.7	0.0	0.2	104	6.4

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[1] Prepared from information and data in the September 1969 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

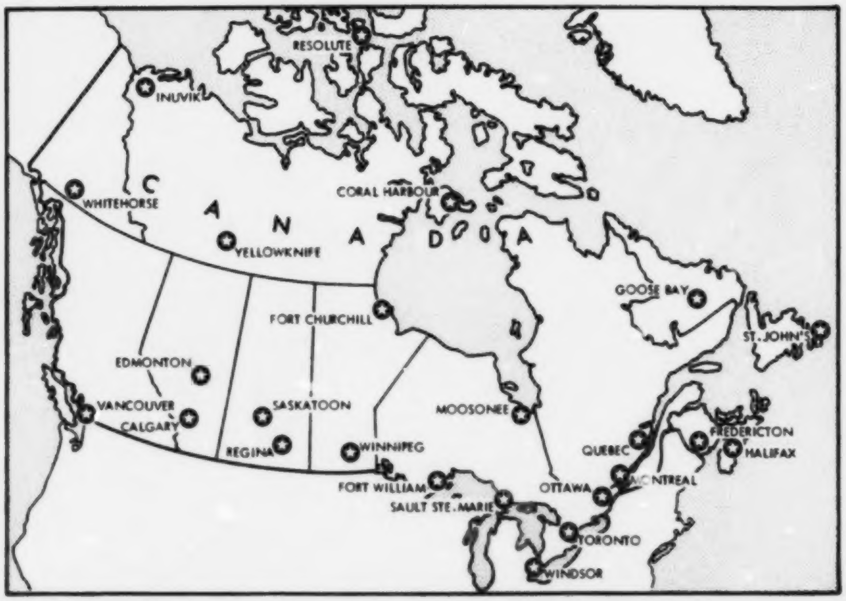
RESOLUTE
INUVIK
C A N A D A
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
FORT CHURCHILL
ST. JOHN'S
EDMONTON
SASKATOON
MOOSONEE
VANCOUVER
CALGARY
FREDERICTON
HALIFAX
REGINA
WINNIPEG
QUEBEC
MONTREAL
FORT WILLIAM
OTTAWA
SAULT STE. MARIE
TORONTO
WINDSOR

Figure 3. Canadian air and precipitation sampling stations

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3. Mexican Air Monitoring Program January and February 1969

National Commission of Nuclear Energy
México, D. F.

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energia Nuclear (CNEN), México, D. F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D. F.; Mérida; Veracruz; San Luis Potosí and Ensenada. Staff members of the DRS operate the station at México, D. F., while the other four stations are manned by members of the Centro de Prevision del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6 by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Secciónde Radioactividad Ambiental, CNEN, in México, D. F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of randon and thoron daughters. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of five samples per month were needed to get a reliable average radioactivity at each station (*1*).

The maximum, minimum, and average beta radioactivity in surface air during January and February 1969 are presented in tables 3 and 4.

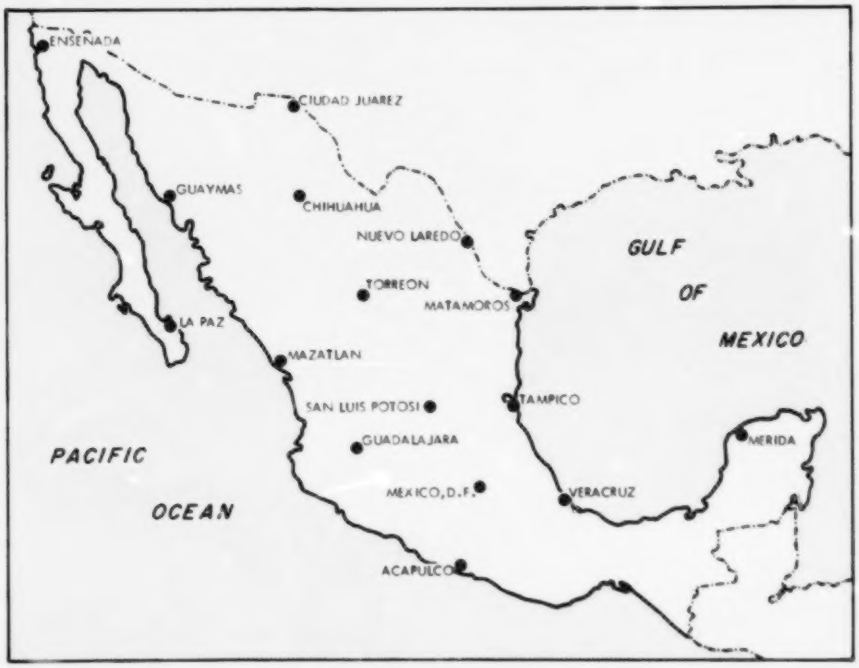

Figure 4. Mexican air sampling stations

Table 3. Mexican gross beta radioactivity of airborne particulates January 1969

Station	Number of samples	Gross beta radioactivity (pCi/m^3)		
		Maximum	Minimum	Average
Acapulco	NS			
Chihuahua	3	0.1	<0.1	
Ciudad Juarez	NS			
Ensenada	5	.4	.1	0.2
Guadalajara	NS			
Guaymas	NS			
La Paz	NS			
Matamoros	NS			
Mazatlan	NS			
Mérida	NS			
México, D.F	2	.2	< .1	
Nuevo Laredo	6	.3	.1	.2
San Luis Potosí	NS			
Tampico	NS			
Torreon	6	.3	.1	.2
Veracruz	1	.1	.1	

NS, no sample, station temporarily shutdown.

Table 4. Mexican gross beta radioactivity of airborne particulates February 1969

Station	Number of samples	Gross beta radioactivity (pCi/m^3)		
		Maximum	Minimum	Average
Acapulco	14	0.2	0.1	0.1
Chihuahua	3	.3	.2	.2
Ciudad Juarez	4	.2	.1	.1
Ensenada	1	.1	.1	
Guadalajara	NS			
Guaymas	NS			
La Paz	NS			
Matamoros	NS			
Mazatlan	8	.4	.1	.3
Mérida	15	.2	.1	.1
México, D.F	2	.2	.1	
Nuevo Laredo	NS			
San Luis Potosí	NS			
Tampico	NS			
Torreon	NS			
Veracruz	14	.2	<.1	.1

NS, no sample, station temporarily shutdown.

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3. Pan American Air Sampling Program
August 1969

Pan American Health Organization and
U.S. Public Health Service

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling locations are shown in figure 5. It should be noted that a new sampling station has been established in Cuenca, Ecuador. Analytical techniques were described in the January 1968 *Radiological Health Data and Reports*. The June 1969 air monitoring results from the participating countries are given in table 5.

Table 5. Summary of gross beta radioactivity in Pan American surface air, August 1969

Station location		Number of samples	Gross beta radioactivity (pCi/m^3)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	17	0.35	0.00	0.07
Bolivia:	La Paz	4	.26	.07	.10
Chile:	Santiago	31	.27	.02	.14
Colombia:	Bogota	17	.02	.00	.01
Ecuador:	Cuenca	17	.06	.01	.02
	Guayaquil	10	.13	.04	.07
	Quito	16	.01	.00	.00
Guyana:	Georgetown	14	.07	.00	.04
Jamaica:	Kingston	16	.30	.03	.17
Peru:	Lima	6	.15	.06	.10
Venezuela:	Caracas	16	.29	.01	.05
West Indies:	Trinidad	19	.23	.01	.06
Pan American summary		183	0.35	0.00	0.07

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m^3 are reported and used in averaging as 0.00 pCi/m^3.

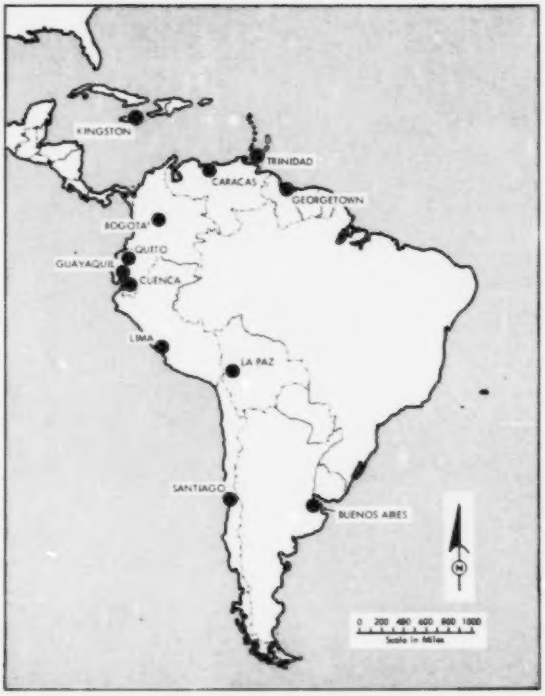

Figure 5. Pan American Air Sampling Program stations

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(*1*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (December 1961).

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(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(*6*) VASQUEZ, M. and R. M. DE NULMAN. Estudios sobre la radioactividad ambiental en la Republica Mexicana, 1963-1965. Comisión Nacional de Energía Nuclear, Dirección General de Seguridad Radiologica (1966).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Alpha Radioactivity in Colorado Uranium Mines 1961-1968

Colorado Bureau of Mines[1]

The Colorado Bureau of Mines with the cooperation of the mine operators has been inspecting underground uranium mines for concentrations of radon daughters since 1961. Using a portable air sampler, a 10 to 15-liter sample of air is taken at each of several positions in the mine. After allowing the filter to decay for 40 to 90 minutes, the alpha radioactivity is measured with an alpha survey meter. Applying the appropriate correction and calibration factors, the counts per minute from the survey meter are converted into working levels.[2] Table 1 presents a comparison of levels of alpha radioactivity in terms of working levels found in operating uranium mines for the years 1961 through 1968. During this period, the percentage of mines containing alpha radioactivity concentrations of 3.0 working levels or less increased from 72.5 to 98.7 percent.

Results of mines inspections for January–December 1968 are presented in table 2.

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[1] Taken from "A Summary of Mineral Industry Activities in Colorado, 1967" Colorado Bureau of Mines and personal correspondence with the Colorado Bureau of Mines.

[2] One "working level" is defined as any combination of radon daughters in 1 liter of air that will result in the ultimate emission of 1.3×10^5; MeV of potential alpha-particle energy. The numerical value of the working level is derived from the alpha-particle energy released by the total decay of the short-lived radon daughter products at radioactive equilibrium with 100 pCi of radon–222 per liter of air.

Table 1. Results of mine inspections in Colorado, 1961–1968

Average working level (WL) range	Percent of mines in range							
	1961	1962	1963	1964	1965	1966	1967	1968
≤ 1.0 WL	45	52	40.5	43	52	60	67	83.92
> 1.0 WL – 3.0 WL	27.5	38	47	41	41.25	34.5	27.5	14.82
> 3.0 WL – 5.0 WL	23	10	12.5	16	6	5.5	4.75	.42
> 5.0 WL – 10.0 WL					.75		.5	.63
>10.0 WL	4.5						.25	.21
Total	100	100	100	100	100	100	100	100

Table 2. Results of mine inspections in Colorado, January–December 1968

Average working level (WL) range	January–March 1968			April–June 1968			July–September 1968			October–December 1968		
	Number of mines	Percent of mines in range	Cumulative percent of mines	Number of mines	Percent of mines in range	Cumulative percent of mines	Number of mines	Percent of mines in range	Cumulative percent of mines	Number of mines	Percent of mines in range	Cumulative percent of mines
≤ 1.0 WL	104	80.62	80.62	100	85.47	85.47	95	79.83	79.83	103	90.35	90.35
> 1.0 WL – 3.0 WL	23	17.83	98.45	15	12.82	98.29	22	18.49	98.32	11	9.65	100.00
> 3.0 WL – 5.0 WL	1	.78	99.23	1	.86	99.15	0	0	98.32	0		
> 5.0 WL – 10.0 WL	1	.77	100.00	1	.85	100.00	1	.84	99.16	0		
>10.0 WL	0	0	100.00	0	0	100.00	1	.84	100.00	0		
Total	129			117			119			114	100.00	

Strontium-90 in Human Bone, October-December 1968[1]

Bureau of Radiological Health
U.S. Public Health Service

To obtain data on the concentration of strontium-90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. Analyses of selected samples of people in older age groups have shown their bone strontium-90 content to be low and age-independent (*1*). Consequently, the target population includes children and young adults up to 25 years of age.

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained postmortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally, this amount is readily available from older children, but it presents some difficulties from the standpoint of infants and children under 5 years of age. Most specimens received to date have been vertebrae and ribs.

Laboratory procedures

The bones are analyzed at Northeastern Radiological Health Laboratory of the Bureau of Radiological Health at Winchester, Mass. Sample collection and preparation are explained elsewhere (*2*). Strontium-90 is measured by tributyl phosphate extraction of its yttrium daughter, which is precipitated as an oxalate. The strontium-90 content is then calculated (*3*) from the yttrium-90 activity. For the purpose of maintaining analytical reproducibility, "blind" duplicate analyses are performed on 10 to 20 percent of the samples. To further check and maintain analytical accuracy, synthetic "bone ash" samples (calcium phosphate spiked with strontium-90) are analyzed periodically and cross-check analyses are carried out quarterly with the Health and Safety Laboratory of the AEC, which performs similar analyses.

The analytical results for strontium-90 in individual bones from persons dying during the fourth quarter (October-December) of 1968 are presented in table 1 in order of increasing age within each geographical region. These regions are indicated in figure 1. Reported values are

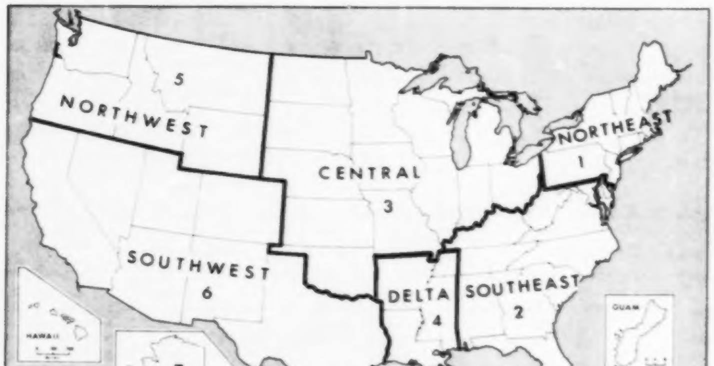

Figure 1. Geographical regions for human bone sampling

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[1] Period during which death or surgical procedure occurred.

Table 1. Strontium-90 in human bone, October–December 1968

Bone region and State		Bone type[a]	Age[b] (years)	Sex	Strontium-90 concentration[c] (pCi/kg bone)	Calcium concentration (g/kg bone)	^{90}Sr/Ca (pCi/g)
Northeast:	N.Y	V	3	F	87.0 ± 9.3	34.5	2.52
		V	4	M	119.0 ± 8.7	27.6	4.31
		V	5	F	57.4 ± 5.5	21.3	2.69
	Pa	V	6	M	84.5 ± 8.7	30.9	2.73
	N.Y	V	6	F	130.0 ± 11.0	38.8	3.35
	Vt	V	7	M	82.3 ± 9.3	33.8	2.43
	N.Y	V	7	M	131.0 ± 12.0	53.7	2.43
	Pa	V	9	F	86.1 ± 8.0	41.4	2.07
	Mass	V	10	M	70.9 ± 6.4	35.7	1.98
		V	11	M	97.7 ± 10.0	34.8	2.80
	Vt	V	12	M	78.8 ± 9.5	34.2	2.30
	N.Y	V	12	F	62.9 ± 7.0	32.4	1.94
	N.J	V	13	F	134.0 ± 9.5	43.6	3.07
	N.Y	V	13	M	46.1 ± 6.2	26.5	1.73
		V	14	M	83.1 ± 10.0	39.2	2.11
		V	14	M	74.7 ± 10.0	42.2	1.77
		V	15	F	74.2 ± 7.7	43.7	1.69
	Conn	V, R	16	M	99.4 ± 7.9	42.9	2.31
	N.Y	V	17	F	128.0 ± 9.7	48.8	2.62
	Mass	V	18	M	127.0 ± 16.0	58.3	2.17
	Vt	V	19	M	145.0 ± 10.0	58.2	2.49
	N.J	V	19	M	102.0 ± 11.0	45.4	2.24
		V	20	M	98.1 ± 9.0	34.6	2.83
	Pa	V	20	M	85.2 ± 10.0	51.6	1.65
	Mass	V	21	M	133.0 ± 13.0	45.3	2.93
	Vt	V	21	M	74.1 ± 9.9	51.3	1.44
		V	21	M	162.0 ± 15.0	63.0	2.57
	N.J	V	21	M	132.0 ± 10.0	68.6	1.92
Southeast:	N.C	V	2	F	101.0 ± 10.0	32.3	3.12
	N.Y	V	5	F	49.5 ± 5.2	22.9	2.16
	S.C	V	5	M	98.8 ± 9.5	30.0	3.29
	Md	V	13	M	90.0 ± 10.0	41.7	2.15
	S.C	V	13	F	188.0 ± 14.0	52.4	3.58
		V	14	F	98.8 ± 8.3	33.2	2.97
	Md	V	15	F	138.0 ± 13.0	71.4	1.93
		V	15	F	184.0 ± 15.0	70.2	2.62
		V	16	M	176.0 ± 13.0	66.7	2.63
		V	17	M	107.0 ± 10.0	54.0	1.98
	Ga	V	17	M	145.0 ± 9.9	59.9	2.42
	Md	V	18	M	188.0 ± 15.0	61.4	3.06
		V	18	M	293.0 ± 14.0	53.1	5.51
		V	18	M	140.0 ± 11.0	61.5	2.27
		V	19	F	146.0 ± 15.0	53.3	2.73
		V	19	M	135.0 ± 12.0	74.2	1.81
		V	20	F	117.0 ± 10.0	53.5	2.18
		V	20	M	101.0 ± 8.3	46.6	2.16
		V	20	M	119.0 ± 9.6	58.9	2.02
	S.C	V	20	M	99.0 ± 8.0	39.1	2.53
	Ga	V	20	M	84.3 ± 8.3	51.9	1.62
	Md	V	21	M	94.3 ± 10.0	50.0	1.88
		V	21	M	108.0 ± 11.0	49.5	2.18
	W. Va	V	22	F	61.0 ± 7.2	37.8	1.61
	Md	V	22	M	183.0 ± 16.0	63.4	2.88
		V	22	M	101.0 ± 12.0	74.8	1.35
		V	22	F	103.0 ± 9.2	50.6	2.03
		V	22	M	140.0 ± 12.0	59.3	2.36
		V	24	M	77.1 ± 7.8	50.2	1.53
		V	24	M	106.0 ± 11.0	52.8	2.00
	S.C	V	24	F	95.1 ± 10.0	49.4	1.92
	Md	V	25	M	124.0 ± 10.0	54.1	2.29
Central:	Wisc	V	1	M	59.3 ± 7.2	29.5	2.01
	Ohio	V	2	M	127.0 ± 11.0	45.0	2.82
	Wisc	V	4	F	61.9 ± 7.5	31.0	1.90
		V	4	M	134.0 ± 9.2	18.0	7.44
		V	4	F	52.1 ± 6.1	28.5	1.82
		V	8	M	40.7 ± 5.2	22.1	1.84
		V	8	F	89.9 ± 9.4	36.9	2.43
		V	8	M	46.5 ± 5.5	22.4	2.07
	Ohio	V	12	M	103.0 ± 8.6	35.5	2.90
		V	15	M	120.0 ± 9.8	66.4	1.80
	Mich	V	15	M	85.6 ± 8.2	49.9	1.71
	Ohio	V	16	M	94.0 ± 11.0	58.3	1.61
		V	16	M	165.0 ± 16.0	67.4	2.44
		V	17	M	120.0 ± 13.0	88.5	1.35
		V	18	M	206.0 ± 15.0	76.8	2.68
		V	18	M	186.0 ± 17.0	90.7	2.05
		V	21	M	111.0 ± 12.0	74.6	1.48
		V	23	M	200.0 ± 16.0	76.4	2.61
Northwest:	Ore	V	1	M	51.1 ± 7.1	26.3	1.94
		V	1	M	65.2 ± 7.6	27.0	2.41
		V	1	M	99.3 ± 9.2	32.1	3.09
		V	4	M	106.0 ± 10.0	32.9	3.22
		V	11	M	86.2 ± 7.5	30.7	2.80
	Wash	V	16	M	125.0 ± 9.6	48.3	2.58
	Ore	LB	18	M	296.0 ± 13.0	175.0	1.69
		V	18	M	94.3 ± 9.3	46.6	2.02
		V	18	M	153.0 ± 11.0	52.2	2.93
		V	19	M	71.0 ± 8.9	44.5	1.59

See footnotes at end of table.

Table 1. Strontium-90 in human bone, October–December 1968—Continued

Bone region and State		Bone type[a]	Age[b] (years)	Sex	Strontium-90 concentration[c] pCi/kg bone)	Calcium concentration (g/kg bone)	^{90}Sr/Ca (pCi/g)
Northwest:	Ore	V	20	F	112.0 ± 13.0	58.0	1.93
		LB	20	M	436.0 ± 23.0	224.0	1.79
		SK	21	F	402.0 ± 22.0	227.0	1.77
		V	22	M	149.0 ± 16.0	76.9	1.93
		V	23	M	69.4 ± 9.7	55.2	1.25
		V	25	F	72.8 ± 7.9	60.5	1.20
		V	25	F	85.9 ± 11.0	51.2	1.67
Southwest:	Colo	V	15	F	62.6 ± 9.8	52.1	1.20
	Hawaii	V	18	M	57.8 ± 7.6	46.7	1.23
	Colo	V	19	F	63.3 ± 8.2	51.8	1.22
		V	19	M	76.1 ± 11.0	54.7	1.39
	Calif	V	20	M	45.5 ± 7.2	45.3	1.00
	Colo	V	22	F	67.3 ± 8.4	61.3	1.09
		V	24	F	100.0 ± 14.0	61.4	1.62
		V	24	M	113.0 ± 13.0	72.8	1.55
		V	24	M	78.3 ± 8.8	55.6	1.40
North:	Alaska	R	18	M	382.0 ± 38.0	120.0	3.18
		R	18	F	200.0 ± 35.0	137.0	1.46
		R	19	M	332.0 ± 37.0	126.0	2.63
		R	23	F	189.0 ± 37.0	107.0	1.77

[a] Type of bone, V, vertebrae; R, rib; SK, skull; LB, long bone.
[b] Age given as of last birthday prior to death.
[c] Two-sigma counting error.

given in picocuries of strontium-90 per kilogram of bone (as a rough indication of dose) and per gram of calcium (for comparison with other data and for purposes of model development). Two-sigma counting errors are reported for the bone concentration.

Following the pattern of earlier reports, subsequent articles will continue to provide interpretation of the data at appropriate stages in the program (*2-5*).

Recent coverage in *Radiological Health Data and Reports*

Period	Issue
October–December 1967	February 1969
January–March 1968	April 1969
April–June 1968	July 1969
July–September 1968	September 1969

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(*2*) WEISS, E. S., W. H. LAND, K. H. FALTER, and R. M. HALLISEY. Strontium-90 content of human bones, 1961–1963. Radiol Health Data 5:231–239 (May 1964).

(*3*) PUBLIC HEALTH SERVICE, NORTHEASTERN RADIOLOGICAL HEALTH LABORATORY. Analysis of environmental samples, chemical and radiochemical procedures, NERHL 64-1. Northeastern Radiological Health Laboratory, Winchester, Mass. (April 1964).

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Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major AEC installatons. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the AEC Manual.[1]

Summaries of data from the environmental radioactivity monitoring reports follow for the Mound Laboratory and the Neutron Devices Department (formerly known as Pinellas Peninsula Plant).

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[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0524 of the AEC Manual.

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1. Mound Laboratory[2]
July–December 1968

Monsanto Research Corporation
Miamisburg, Ohio

The environmental monitoring program for Mound Laboratory is planned and coordinated with all of the projects conducted at the laboratory. Air and water monitoring in the uncontrolled environs surrounding the laboratory is specified for the radionuclides which could be released to the environment. Only polonium-210, plutonium-238, and hydrogen-3 (tritium) are potential environmental contaminants.

Air monitoring

Mobile air monitoring equipment, mounted on a 1-ton panel truck, for measurement of tritium and collection of particulate alpha-particle emitters was used in the routine monitoring of environmental air within a radius of 20 miles from the laboratory during the collection period. Since the sampling zone is dependent on the wind direction it is possible that air samples from all zones will not be collected during the reporting period.

Airborne polonium and plutonium particulates are collected with a high-volume air sampler. The filter papers are then processed such that counting results are specific for polonium and plutonium. One fourth of each filter paper is processed by spontaneous deposition to isolate polonium. The remaining three fourths of each filter paper is processed chemically to remove polonium. The remaining alpha radioactivity is interpreted as plutonium; however, some of this alpha radioactivity is probably due to naturally occurring alpha-particle emitters.

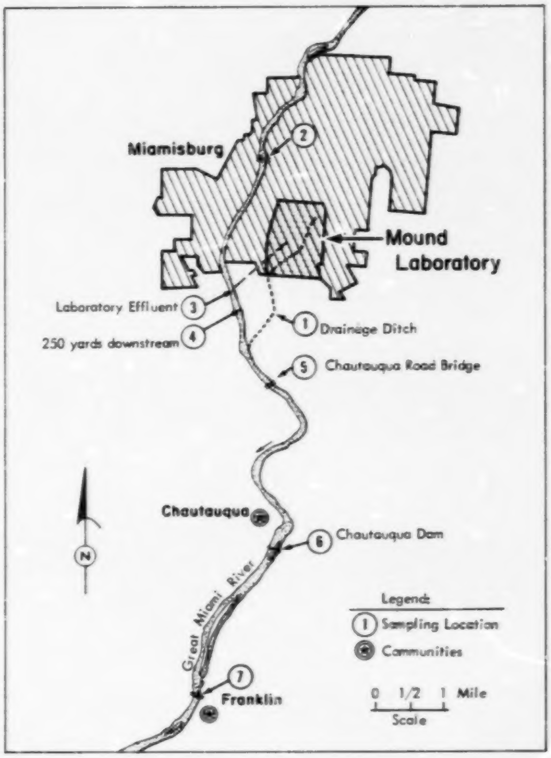

Figure 1. Water sampling locations, Mound Laboratory

Airborne tritium is monitored by bubbling air through a liquid scintillation counting solution with p-dioxane as the organic solvent. The counting solution is counted directly in a liquid spectrometer.

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[2] Summarized from "Environmental Monitoring Report, July–December 1968" (MLM-1619).

The results of the airborne monitoring program are presented in tables 1, 2 and 3. The average concentration of plutonium, polonium, and tritium in the environment are below the AEC radiation protection standards.

Table 1. Atmospheric monitoring of polonium-210, Mound Laboratory environs, July–December 1968

Range (miles)	Number of samples	Concentration (fCi/m³)[a]		Average as percent of AEC standards[b]
		Maximum	Average	
0– 3 (upwind)	16	41.2	17.8	0.09
0– 3 (downwind)	16	57.0	19.7	.10
3– 5 (downwind)	16	36.7	21.0	.10
5–10 (downwind)	16	114.6	21.3	.11
10–15 (downwind)	16	100.2	28.0	.14
15–20 (downwind)	16	51.5	15.2	.08

[a] Lowest detectable level (LDL) for polonium–210 in air is 8.0 fCi/m³ for samples collected 0–3 miles upwind, 3–5 miles downwind, 5–10 miles downwind, and 10–15 miles downwind. The LDL is 5.3 fCi/m³ for samples collected 0–3 miles downwind and 15–20 miles downwind. All vaules which were not detectable were set equal to these values when average values were calculated.

[b] The applicable AEC radiation protection standard for polonium–210 in air is 20 pCi/m³.

Table 2. Atmospheric monitoring of plutonium-238, Mound Laboratory environs, July–December 1968

Range (miles)	Number of samples	Concentration (fCi/m³)[a]		Average as percent of AEC standards[b]
		Maximum	Average	
0– 3 (upwind)	14	24.2	7.3	10.43
0– 3 (downwind)	14	27.6	6.3	9.00
3– 5 (downwind)	14	43.5	11.5	16.43
5–10 (downwind)	14	23.0	8.2	11.71
10–15 (downwind)	14	29.6	9.9	14.14
15–20 (downwind)	14	18.5	5.7	8.14

[a] Lowest detectable limit (LDL) for plutonium in air is 1.3 fCi/m³ for samples collected 0–3 miles upwind, 3–5 miles downwind, 5–10 miles downwind, and 10–15 miles downwind. The LDL is 0.9 fCi/m³ for samples collected 0–3 downwind and 15–20 miles downwind. All values which were not detectable were set equal to these values when average values were calculated.

[b] The applicable AEC radiation protection standard for plutonium–238 in air is 70 fCi/m³.

Table 3. Atmospheric monitoring tritium, Mound Laboratory environs, July–December 1968

Range (miles)	Number of samples	Concentration (nCi/m³)[a]		Average as percent of AEC standards[b]
		Maximum	Average	
0– 3 (upwind)	17	2.63	2.11	1.05
0– 3 (downwind)	17	41.74	4.38	2.19
3– 5 (downwind)	17	3.34	2.17	1.08
5–10 (downwind)	17	2.33	2.02	1.01
10–15 (downwind)	17	3.10	2.07	1.03
15–20 (downwind)	17	2.53	2.04	1.02

[a] Lowest detectable limit for tritium in air is 2.00 nCi/m³. All values which were not detectable were set equal to this value when average values were calculated.

[b] The applicable AEC radiation protection standard for tritium in air is 200 nCi/m³.

Water monitoring

Liquid radioactive waste materials from polonium and plutonium operations at the laboratory are processed separately to reduce the concentrations of these radionuclides to a level at which they may be discharged to the environment. Treated polonium liquid waste is discharged to the Great Miami River via a closed sewer line which also carries the treated plant sewage. The treated plutonium waste is discharged to a drainage ditch which runs through the plant site and eventually reaches the river.

Helium-3, which is purified at the Mound Laboratory, contains small quantities of tritium. In addition, tritium is recovered from various AEC tritium-contaminated wastes. Liquid waste generated by these operations is treated (diluted with water when necessary) and is discharged to the same closed sewer line as polonium. Some tritium-contaminated liquid wastes are discharged to the drainage ditch which runs through the site and eventually reaches the river.

Water samples are collected weekly from the Great Miami River, the drainage ditch and two ponds northeast of Mound Laboratory (figure 1). The average concentrations of plutonium and tritium in water discharged to the environment were well below the AEC radiation protection standards. The data indicate that the average concentration of polonium in the plant effluent water for the 6-month period, July–December 1968, was 1.7 times the AEC radiation protection standard. However, the average concentration of polonium in the effluent water for the 12-month period was 0.87 times the standard which meets the stringent water pollution standards of the AEC. The average concentration during the 6-month period, July–December, resulted from a break in buried waste lines which allowed polonium contaminated liquid waste to enter an adjacent sanitary line, thus by-passing the radioactive waste disposal facility. The lines were repaired, and the concentration of polonium in the effluent returned to normal. Average concentrations of tritium, polonium–210 and plutonium–238 are given in table 4 for July–December 1968.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July–December 1967	September 1968
January–June 1968	May 1969

Table 4. Offsite water monitoring for radioactivity, Mound Laboratory environs July–December 1968

Nuclide and sampling location[a]	Number of samples	Concentration	
		Maximum	Average[b]
Polonium-210[c] (pCi/liter)			
1 (Drainage ditch)	20	47.7	5.54
2 (Upstream from laboratory)	20	3.60	1.94
3 (Laboratory effluent)	20	8,016	1,202
4 (250-yards downstream)	20	50.4	8.9
5 (Chautauqua Road Bridge)	20	49.5	7.65
6 (Chautauqua Dam)	20	298	16.4
7 (Franklin, Ohio)	20	63.1	7.70
8 (Pond, opposite V.A. hospital, Dayton, Ohio, 8 mi. NE of Mound Laboratory)	20	1.8	1.8
9 (Pond, Possum Creek Reserve, Dayton, Ohio, 6 mi. NE of Mound Laboratory)	20	3.60	1.94
Plutonium-238 (pCi/liter)			
1 (Drainage ditch)	18	254	60
2 (Upstream from laboratory)	18	8.11	5.41
3 (Laboratory effluent)	18	157	25.2
4 (250-yards downstream)	18	66.7	8.56
5 (Chautauqua Road Bridge)	18	27.9	6.31
6 (Chautauqua Dam)	18	14	6.31
7 (Franklin, Ohio)	18	10.8	5.86
8 (Pond, opposite V.A. Hospital, Dayton, Ohio, 8 mi NE of Mound Laboratory)	18	25.2	5.86
9 (Pond, Possum Creek Reserve, Dayton, Ohio, 6 mi NE of Mound Laboratory)	18	9.46	4.95
Hydrogen-3 (tritium) (μCi/liter)			
1 (Drainage ditch)	20	7.76	1.10
2 (Upstream from Laboratory)	20	1.04	.10
3 (Laboratory effluent)	20	2.74	.25
4 (250-yards downstream)	20	.05	.06
5 (Chautauqua Road Bridge	20	.05	.05
6 (Chautaugua Dam)	20	.05	.05
7 (Franklin, Ohio)	20	.05	.05
8 (Pond, opposite V.A. Hospital, Dayton, Ohio, 8 mi. NE of Mound Lab)	20	.36	.07
9 (Pond, Possum Creek Reserve, Dayton, Ohio, 6 mi. NE of Mound Lab.)	20	.05	.05

[a] See figure 1 for number of sampling locations.

[b] The applicable AEC radiation protection standards for uncontrolled area are as follows:

Polonium-210 in water: 700 pCi/liter
Plutonium-238 in water: 5 nCi/liter.
Hydrogen-3 in water: 3 μCi/liter

[c] Minimum detectable level for polonium-210 in water is 1.80 pCi/liter.
Minimum detectable level for hydrogen-3 in water is 50 nCi/liter.
Minimum detectable level for plutonium-238 in water is 4.50 pCi/liter.
All samples which were not detectable were set equal to their respective minimum detectable level when average values were calculated.

2. Neutron Devices Department[3]
January–June 1968

General Electric Company
St. Petersburg, Florida

The Neutron Devices Department, shown in figure 2, is an electronic component production facility. The plant maintains an environmental monitoring program to measure the levels of radioactive environmental contamination associated with plant effluents. These measurements serve as an index of the effectiveness of the plants's contamination control measures. Effluent radioactivity concentrations and associated atmospheric and stream dilution factors indicate offsite radioactivity concentrations encountered by the general population are substantially lower than the guides for continuous non-occupational exposure established by AEC and documented in the "AEC Manual."

Sewer effluent monitoring

A combined sewer effluent sample is obtained daily near the perimeter of the plant's property. During the sampling period 5 of 234 samples analyzed showed detectable concentrations of tritium ($>$ 90 nCi/liter). The maximum concentration (480 nCi/liter, detected on March 8, 1968)

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[3] Summarized from "Environmental Monitoring, January 1 through June 30, 1968" General Electric Company, Neutron Devices Department, St. Petersburg, Fla.

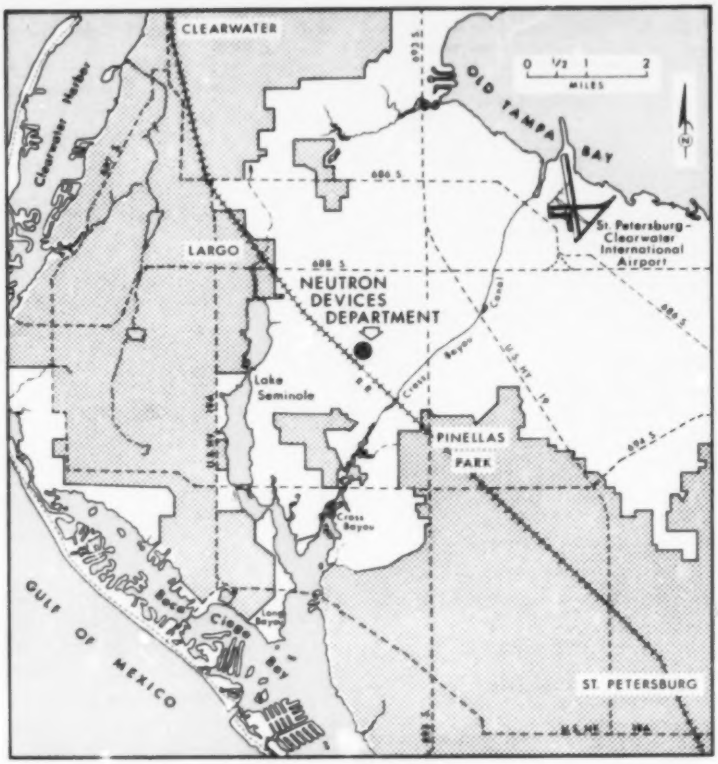
CLEARWATER
Clearwater Harbor
OLD TAMPA BAY
0 1/2 1 2
MILES
N
St. Petersburg-Clearwater International Airport
LARGO
NEUTRON DEVICES DEPARTMENT
Lake Seminole
Cross Bayou Canal
U.S. HY. 19
R.R.
PINELLAS PARK
Cross Bayou
Long Bayou
Boca Ciega Bay
GULF OF MEXICO
ST. PETERSBURG
688 S.
686 S.
694 S.
692 S.
593 S.
U.S. HY. 19A

Figure 2. Location of the Neutron Devices Department

represented 16 percent of the continuous non-occupational exposure guide. Calculations based on radioactivity releases from the process waste system, and the plant's water discharges, indicate that the average tritium concentration in the combined sewer effluent for the first half of 1968 was less than 0.5 percent of the AEC radiation protection standard for continuous non-occupational exposure.

Surface water sampling

Surface water samples are collected at monthly intervals at selected locations within 8 miles of the plant. The sampling areas are determined by interrelating the concentrations of radioactivity in exhaust stack effluent with meteorological data. There were no indications of tritium (>90 nCi/liter) in the 92 surface water samples analyzed during the sampling period.

Milk sampling results

Analyses of twelve raw milk samples, collected from one local dairy farm by the Pinellas County Health Department, revealed no detectable concentrations (>90 nCi/liter) of tritium.

Air sampling results

No detectable amounts of tritium gas (>20 $\mu Ci/m^3$) or tritium oxide (>5.0 nCi/m^3) were found in two samples of air obtained downwind from the exhaust stack at the perimeter of the plant property.

Recent coverage in *Radiological Health Data and Reports*

Period	Issue
January–June 1967	February 1968
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Reported Nuclear Detonations, November 1969

(Includes seismic signals from foreign test areas)

The U.S. Atomic Energy Commission announced that a nuclear test of low-intermediate yield (20 to 200 kilotons TNT equivalent) was conducted underground at its Nevada Test Site on November 21, 1969.

Announcement was also made by the U.S. Atomic Energy Commission that the United States recorded seismic signals on November 29, 1969, originating from the Soviet nuclear test area in the Semipalatinsk region. The signals were equivalent to those of a nuclear test in the intermediate yield range.

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SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

OFFSITE RADIOLOGICAL SURVEILLANCE FOR PROJECT GASBUGGY, JUNE 1967–JULY 1968. *John R. McBride and Dixon Hill. Radiological Health Data and Reports, Vol. 10, December 1969*, pp. 535–546.

Project Gasbuggy, an experiment to stimulate gas recovery by nuclear means, was conducted on December 10, 1967, as part of the Atomic Energy Commission's (AEC) Plowshare program. The Public Health Service by Memorandum of Understanding with the AEC is responsible for a comprehensive offsite radiological safety program. The data obtained during this program have documented that no radioactivity was introduced into the environment as a result of the Project Gasbuggy detonation. Surveillance of the El Paso natural gas producing wells near the Gasbuggy experiment was conducted to insure that gas contaminated with radioactivity was not present.

Keywords: Project Gasbuggy, offsite surveillance, natural gas, Plowshare, air, water, milk, external radiation.